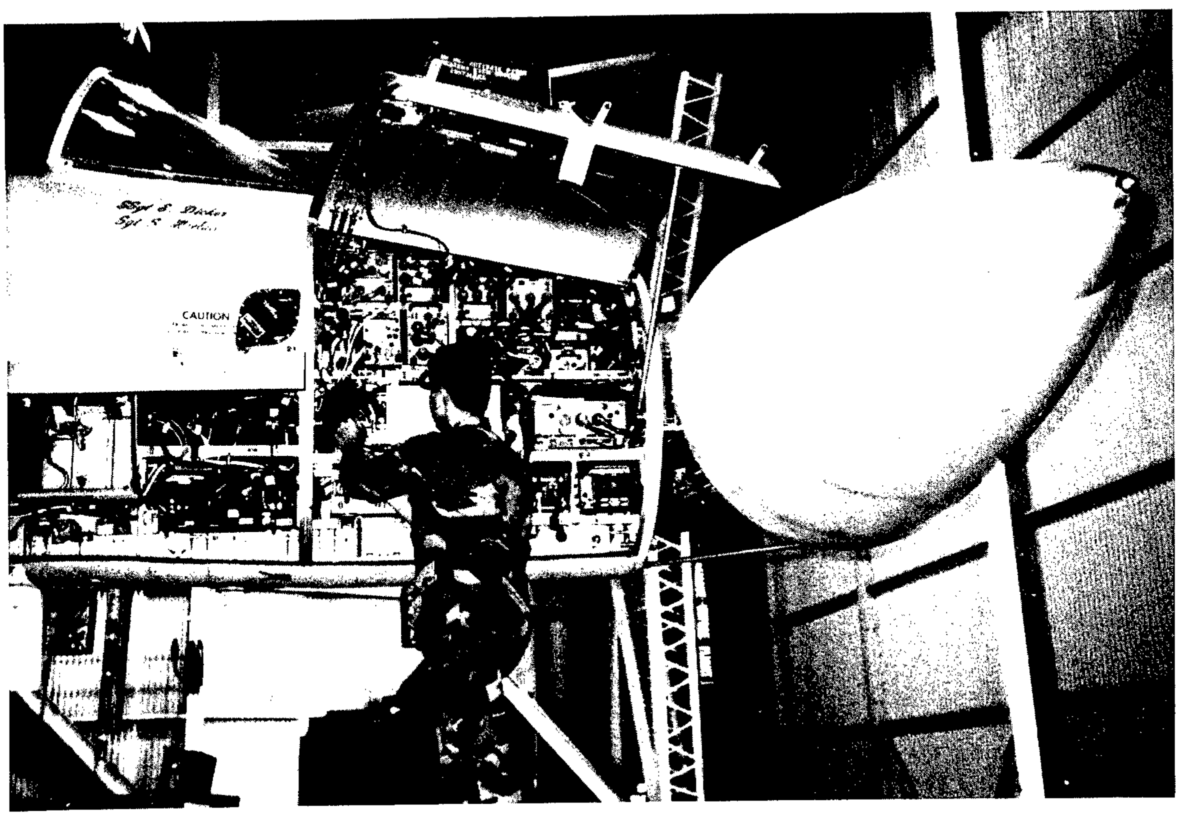
MAINTENANCE: The Heart of Logistics

SPRING 1989

AIR FORCE JOURNAL of LOGISTICS



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DEPARTMENTS

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Transformation of Base Level Maintenance Quality Assurance

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Background

Until quite recently, the aircraft maintenance quality program in most major commands had been an inspect-one, report-one type of system. Equipment and personnel performance errors were detected by Quality Assurance (QA) using appraisal inspections and evaluations. However, no effective mechanism existed which quickly identified negative (or potentially negative) performance trends from raw QA inspection/evaluation data. This, in addition to small inspection sample sizes, hampered QA's ability to quickly identify those specific equipment and personnel problem areas requiring immediate attention. QA seldom achieved its goal of effectively identifying and arresting negative performance trends.

The Air Force, however, was not alone in this dilemma. The private sector also encountered similar problems. Economic survival forced them to ''retool'' their quality assurance philosophy. Phillip Hoffer, supervisor of the Quality/Reliability Planning and Analysis Section of Ford Motor Company's Corporate Product Quality Office, explains:

> Traditionally, quality efforts were focused on finding nonconformities *after* they had been produced. Armies of inspectors employed elaborate sampling plans and backup facilities to detect, sort, rework, rehandle, and reinspect nonconforming products. This method of operation placed the quality professional and the quality system in the role of policeman whose job it was to catch and punish the criminal (the production department) when nonconformities were produced. Production and quality were adversaries. (1:24)

Recognizing this, private industry abandoned its after-the-fact quality methodology (referred to as ''defect detection'' by Hoffer) and replaced it with a ''defect prevention'' approach. Defect prevention can be described as a method whereby the (production) process is monitored to ''determine when adjustments are required to maintain stability and when changes to the process are called for to reduce its inherent variability.'' (1:25) Atlanta-based Delta Air Lines, long recognized as a leader in the air transportation industry, is an organization that has integrated the defect prevention concept into its maintenance procedures. At Delta, Maintenance Analysis tracks its aircraft by systems and subsystems. Once the company-established number of allowable discrepancies in any system/subsystem is exceeded, Delta's microcomputer-based analysis program generates an outstanding maintenance item (OMI). The OMI keys the analyst to search the aircraft system/subsystem database for a possible cause of the identified trend. Once determined, the analyst notifies Delta Quality Assurance. (3) QA then investigates to determine if the identified trend is valid, what caused the problem, and what can be done to prevent it from recurring in the future. This procedure appears to be successful. Average maintenance reliability of Delta's 244 jets is 98%. (2) The key words in Delta's QA program are *defect prevention*—prevention of future error by continuously ''adjusting'' the maintenance production process.

Ford Motor Company, Delta Air Lines, and others successfully use QA systems which provide real-time, on-line production trend identification. This trend ''flagging'' process allows managers to quickly identify, analyze, and arrest adverse trends in their initial stages of development with the overall objective of preventing future recurrence.

Defect Prevention Finds a Home in TAC

The evolution in quality from defect detection to prevention was not, however, limited to the private sector. In April 1986, Tactical Air Command (TAC) took the lead in the aircraft maintenance QA arena by revamping QA policy and procedures throughout the command. As a result, QA inspectors are now periodically reassigned from the Deputy Commander for Maintenance (DCM) staff to an aircraft maintenance unit (AMU) or branch for a period not to exceed 30 days. During this time, the ''dedicated'' QA inspector is charged with sampling each shift and reporting weekly. Engine and weapon inspectors are assigned to AMUs as well as to selected shops in the maintenance complex. Specialist inspectors are assigned to areas of interest, either flight line (on-equipment) or in-shop (off-equipment), by the QA Chief Inspector. This decentralization of inspectors keeps them in the production areas rather than in the QA office. This increased inspector presence resulted in standardization (one inspector per work center per month) and greater numbers of inspections performed per month (800-1200 per month vice 200-400 per month before the QA reorganization). Increased number of inspections, however, resulted in the creation of a unique problem for TAC Quality Assurance—information overload! The number of inspections and evaluations performed under TAC's new QA guidelines was simply too great for effectively analyzing QA inspection/evaluation data for negative performance trends. Any attempt at defect prevention was thwarted by the sheer volume of raw QA evaluation data. Manual data analysis was met with limited success at best. It was at this point TAC turned to the Air Force Logistics Management Center (AFLMC) for help in solving this problem.

Automated Performance Trend Identification and Analysis Comes of Age

Initial research on this project indicated the Air Force could profit from a reorientation of its QA program toward one more

similar to that found in private industry. With that in mind, we assembled a multidisciplined project team comprised of an aircraft maintenance officer, a maintenance analyst, an operations research analyst, a human factors engineer, and base level QA inspectors "drafted" from the TAC. The result of this concentrated effort was the development of an automated equipment and personnel performance trend identification and analysis system to fit TAC's new QA program. We call the system PEAP—the Personnel Evaluation Analysis Program. PEAP was developed for use on the Zenith Z-248 microcomputer.

PEAP Concept of Operations

The Personnel Evaluation Analysis Program recognizes four categories of QA inspections/evaluations:

(1) Technical—Inspection of equipment following a maintenance inspection or repair action.

(2) Personnel—Evaluation of a maintenance action performed by the aircraft technician or supervisor.

(3) Special—Inspection initiated by higher headquarters, a weapon system manager, or the DCM. This inspection may be conditional or procedural compliance oriented.

(4) Safety/Unsafe Condition—Unsafe act by an individual (Detected Safety Violation) or an unsafe condition in which maintenance personnel are not directly involved (Unsafe Condition Report).

Type Event Codes. Each event evaluated in each of the four categories listed is assigned a type event code (TEC) by the base level Quality Assurance Program Monitor or Deficiency Analyst. A TEC is a three-digit code indicating the type of maintenance performed, and subsequently evaluated, by QA. The first two digits of the TEC are identical to the first two digits of the work unit code (WUC) for the particular system and mission/design/series (MDS) the unit is maintaining. The third digit denotes the type of maintenance inspected for the specific system or event. For example:

TEC 23=Engines (Aircraft)
TEC 23A=Engine Final Major Maintenance
TEC 23B=Engine Final Minor Maintenance
TEC 23C=Engine Removal
TEC 23D=Engine Installation, etc.

Stages of Development. PEAP is comprised of three separate stages:

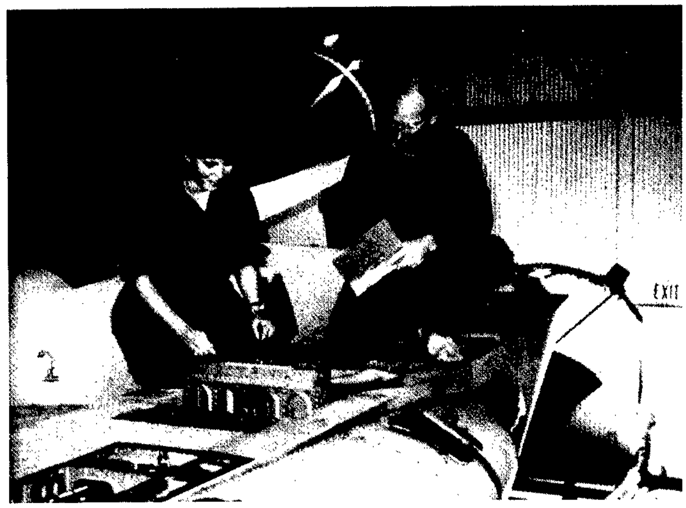
Initial Inspection/Evaluation Stage (see photograph). In this stage, the QA inspector performs an inspection on a piece of equipment or evaluation on a maintenance technician or specialist. This inspection/evaluation data is then entered into the PEAP database.

Analysis Stage. In this stage, PEAP provides nine analytical reports for use by QA personnel, deficiency analysts, and aircraft maintenance managers:

(1) The Type Event Code (TEC) Trending Report. This program provides QA trending information on technical (equipment), personnel, and special categories of QA inspections and evaluations for every TEC and work center in the DCM complex.

(2) "Flagged" TEC Report. This report displays trend data for a specific TEC or work center flagged by PEAP as having a negative (or potentially negative) performance trend.

(3) Graph Values Report. PEAP calculates the trending data



for each individual TEC and work center and stores this information in the PEAP database. Trend data can then be converted into a graphic format.

(4) Work Center Summary. This summary displays the totals, pass rates, and average scores for the different types of QA inspections/evaluations performed in a maintenance organization.

(5) Remarks Identifier Report. PEAP displays all data for a specific remarks identifier code. For example, assume the DCM directs QA to track all foreign objects found during all QA inspections/evaluations in the maintenance complex. Using a remarks identifier code consisting of any user-defined two-digit number, QA can easily track any special interest item such as, in this particular case, foreign objects.

(6) Complete Personnel Evaluation Summary. PEAP displays a summary of every personnel evaluation QA has performed, sorted either alphabetically or numerically, on the name or employee number of every maintenance technician or specialist evaluated by QA.

(7) Single Individual Evaluation History Report. This report displays the totals, pass rates, and average scores for the different types of QA evaluations performed on a single maintenance technician or specialist.

(8) Equipment Serial Number History Report. This report provides both the quantity of each type of inspection performed on a single piece of equipment and detailed inspection data.

(9) Work Center History. PEAP displays the results of every type of inspection QA has performed on a maintenance work center.

QA Redirection Stage. The reports generated in this stage were developed for use by the QA Officer-in-Charge, Noncommissioned Officer-in-Charge, and Chief Inspector to measure and evaluate QA inspector productivity and, if necessary, redirect QA inspection efforts:

(1) Individual QA Inspector Productivity Report. This report displays the total number of inspections/evaluations performed by a single QA inspector broken out by the different categories of inspections, the pass rates for each, and the overall "pass" rate and average score of the individual inspector.

(2) All QA Inspectors Productivity Report. This report is identical to the Individual QA Inspector Productivity Report except that it includes inspection/evaluation data on *all* inspectors assigned to QA.

(3) QA Inspection Requirements Tally Report. This report compares the number of monthly inspections/evaluations

required of QA (by type event code) with the number actually completed. It helps provide QA the flexibility needed to redirect inspection efforts quickly to those maintenance areas identified as being under-evaluated.

PEAP's Impact on Quality

Originally designed for (and subsequently fielded by) TAC, PEAP has been integrated into base level aircraft maintenance QA divisions within Alaskan Air Command (AAC), Military Airlift Command (MAC), and Air Force Reserve (AFRES). The use of PEAP in these MAJCOMs has enabled QA to:

- Successfully identify aircraft maintenance areas displaying negative (or potentially negative) performance trends in their initial stages of development. This process has allowed QA inspectors to redirect inspection efforts quickly to those specific PEAP-identified problem areas.
- Decrease the time required to create QA reports by over 50% when compared to the previous (manual) method. The result has been an increase in time available for QA inspectors to perform additional inspections/evaluations. Consequently, the number of inspections/evaluations performed has increased 55%-65% at base level QA divisions.
- Automatically track both the quantity and quality of inspections and evaluations performed by QA inspectors. Base level QA managers are now able to ascertain quickly which inspector is doing how many inspections and in what areas.
- Accurately track the monthly minimum number of inspections/evaluations required (per type event code). The result—a thorough QA inspection effort in all areas each month.

These facts and figures are important, but it is the feedback from the "customers," the MAJCOM LGMs and base level QA folks, that means the most. Speaking to a MAC logistics conference, Colonel Robert Polk, recently retired MAC/LGM, claimed "PEAP is the best thing to happen to aircraft maintenance in the last fifty years." Most importantly, QA inspectors seem to like it. MSgt John Wendinger, 184th TFG/MAQ, McConnell AFB, Kansas, writes:

> We have been using the PEAP program since August and find it an outstanding tool for us in Quality Assurance. Our jobs have been made easier, and the results have increased our productivity by showing us where our problem areas are so we can better direct our efforts. . . . Thank you for the program. We love it! (4)

We love it also. PEAP, however, is not an end but merely a means to the ultimate objective—the improvement of the quality process.

Where Do We Go From Here?

Brigadier General Philip L. Metzler, HQ USAFE/LG, has afforded the AFLMC the opportunity to develop an enhanced version of PEAP for USAFE. This project, the Quality Assurance Tracking and Trend Analysis System (QANTTAS), will also include an automated product improvement program. QANTTAS will allow QA to not only identify and arrest negative production trends quickly but also to automate the QA product improvement process. The introduction of QANTTAS, in addition to AFLC's Automated Technical Order Management System and Automated Weight and Balance program, will transform base level QA divisions Air Force wide into fully automated DCM staff functions. This base level quality function, although extremely important, is only half the equation. The quality process at AFLC's air logistics centers (ALCs) is the other.

Currently, when two or more aircraft parts are fit together at the depot, the size of their tolerances often determines how well they will match. However, should one part fall at the lower limit of its specification, and a matching part fall at its upper limit, a tight fit is unlikely. Even if the parts are rated acceptable initially, the link between them is likely to wear more quickly than one whose dimensions have been centered more exactly. The Air Force presently adheres to a production process in which aircraft parts all fall within production specifications, but not tightly around the target value. The AFLMC has initiated "QA Future Look" to compare and contrast actual MIL SPEC limits and results to those which might be obtained using a parameter design model similar to that found in the private sector. Like PEAP, the Future Look project team will be multidisciplined.

Conclusion

The Personnel Evaluation Analysis Program was the first phase of an evolutionary process which automatically identifies negative equipment and personnel production trends in their initial stages of development. It has helped change the way we do business by assisting Quality Assurance *build quality into the base level maintenance production process rather than inspect it into the finished product.*

The use of an automated QA program to monitor and flag the inherent variability of the maintenance production process has proven to be a successful technique in improving quality in the aircraft maintenance realm. Without automated QA programs like PEAP and QANTTAS we, as Air Force logisticians, are destined to be left behind.

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"Keep up your bright swords, for the dew will rust them."

Shakespeare

Damage Tolerance Analysis and Structural Integrity in Air Force Aircraft

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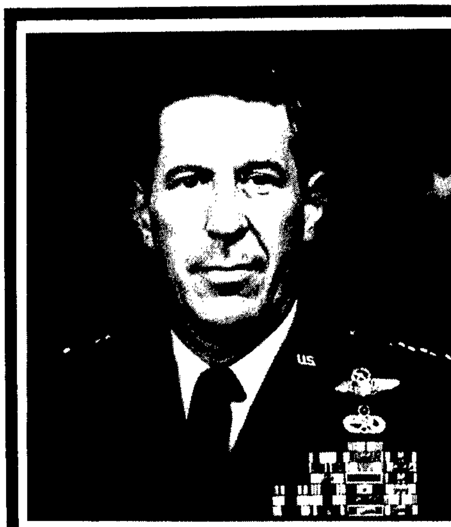


In December 1969, an F-111A with a very small crack in the high-hardness steel structure of the wing pivot fitting went into a 3-G maneuver. Suddenly the crack became unstable and spread across the entire assembly. The wing suffered catastrophic failure and separated from the aircraft. Two crew members were lost, and one of the Air Force's front-line fighters was destroyed.

It is not likely that a crack of this nature would have led to this kind of failure in softer materials like aluminum. But, because of the sensitivity of high-strength materials to small defects, we found out the hard way that such catastrophic failures could result.

This accident, then, prompted the Air Force to develop a new approach for dealing with potential structural failures—one geared toward analyzing the growth of cracks to help design more damage-tolerant airframes and better predict when catastrophic failures would occur. The result of this effort is *damage tolerance analysis (DTA)*.

DTA assumes flaws exist which we cannot always detect. These flaws result initially from the manufacturing process when parts are machined and drilled. Subsequent usage then makes these flaws grow into cracks, which degrade the strength of the structure. DTA focuses on predicting, testing, and analyzing the degradation in strength that results when these cracks grow. By analyzing the growth pattern for a given load history, DTA allows us to predict two things accurately: how large the crack can be before safety is jeopardized, and when that danger point will be reached.

This capability has been particularly important, especially since many of the Air Force's most important aircraft are older than the pilots who fly them. For example, the KC/EC/C-135 was first delivered to the Air Force in 1955 with an initial service life of 10,000 flying hours. Through modifications, including a 13-year re-skinning effort completed last year, the KC-135's structural integrity is now assured to 36,000 hours.

Another example is the B-52. This airplane was designed in 1948 and first flew in 1952. The "G" and "H" models are still in the active inventory. Although the original life was only 5,000 flying hours as a high-altitude bomber, the planes have undergone extensive structural modifications related not only to their age, but also to the demands of flying low-level mission profiles. Structural enhancements performed by the Air Force Logistics Command (AFLC) include a re-winging effort in the early 1960s, a tail-assembly modification in the mid-1960s, and structural fatigue modifications in the mid-to-late 1960s. The point is that we are safely extending the structural life of these aircraft because of tools like DTA, which allow us to make aircraft structures more tolerant of the kinds of flaws introduced in the manufacturing process. I said tools *like* DTA because damage tolerance analysis is only one of several analyses used in the Aircraft Structural Integrity Program (ASIP). ASIP is our umbrella effort to improve structural design, diagnose failures, propose corrective actions, and predict operational life expectancy.

ASIP is involved throughout the life cycle of a weapon system. The DTA part of ASIP is primarily concerned with ensuring aircraft safety by requiring damage tolerant structures capable of accommodating flaws induced during the manufacturing process. DTA allows us to integrate many key elements—stress and load analysis, fracture mechanics, operational load requirements, material crack growth characteristics, residual strength, and nondestructive inspection (NDI) capabilities. It gives us the wherewithal to design for and maintain structural integrity in our aircraft for a specified operational life.

Now how does DTA work? The first step is determining the required design service life in terms of years or total hours. The using command supplies mission descriptions, gross weights, performance requirements, and other parameters relevant to structural design. Headquarters USAF then establishes the design service life. At this point, realistic levels of damage tolerance are defined based on what is needed and the minimal flaw sizes actually achievable in the manufacturing process.

Next comes the actual design of the airframe. Taking into account the design service life, airframe requirements are developed using an extensive database gathered from recorded information on operational aircraft in similar mission segments. The primary focus is on the expected magnitude and frequency of loads the aircraft will experience. Damage tolerance analysis is done to analytically determine the rate at which cracks will grow, based on expected aircraft usage, and the residual strength the structure will have with various size cracks. That way the structural design can be changed to meet life cycle requirements.

The third step in doing DTA is to verify the design with durability tests. Full-scale airplanes are subjected to millions of load applications in the laboratory. The purpose is to ferret out critical structural areas not already identified, to collect and analyze data, and then to develop and test fixes. We want to incorporate required modifications while the system is still in production rather than doing expensive retrofits later on.

Once the durability of the airframe has been tested to the equivalent of two lifetimes, additional damage tolerance testing may also be done. The airframe then goes through a

destructive teardown and inspection to assure all critical areas have been uncovered and properly evaluated.

The final step in DTA is to compare the test results with earlier analytical predictions and make whatever analytical adjustments are warranted. We then develop the Force Structural Maintenance Plan, which identifies all the critical areas and the point in time when safety inspections and modifications must be done. The Plan is also very dynamic, constantly being updated with data from flight load recorders installed on operational aircraft.

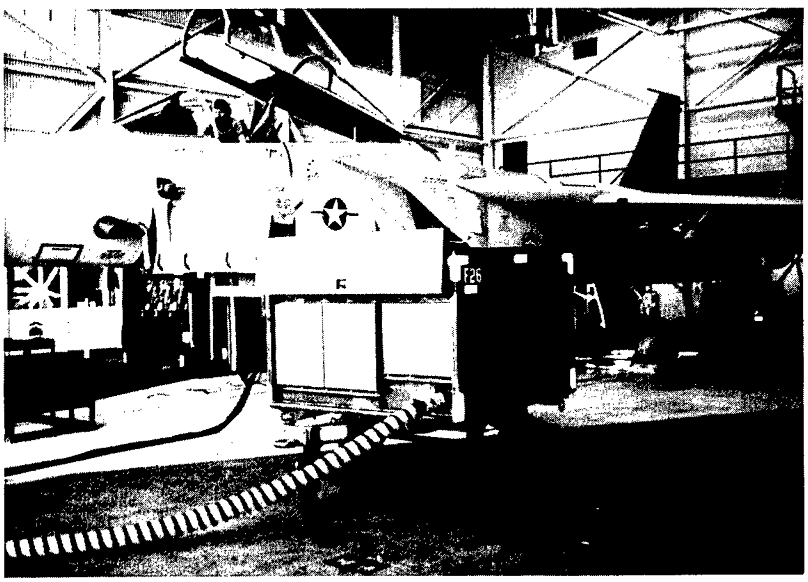
AFLC also has an individual airplane tracking program by tail number which documents, for each flight, such things as mission type, configuration, gross weight, altitude, velocities, etc. That way we can calculate expected crack growth at each critical area for each airplane based on actual usage.

The Aircraft Structural Integrity Management Information System, located at the Oklahoma City Air Logistics Center, collects the recorder data and calculates the accumulated damage at each critical structural area for each airplane. That way, necessary safety inspections and modifications can be accomplished. In fact, we make every effort to predict these requirements far enough in advance to allow the systems program manager to combine this work with other scheduled maintenance.

Modern military and economic realities require the Air Force fly its aircraft longer and in more demanding mission profiles than ever before. Assuring aircraft structural integrity, then, is one of our paramount concerns. The Aircraft Structural Integrity Program gives us a good handle on the various modes of potential structural failures in Air Force aircraft. It lets us zero in on those concerns which must be addressed when designing or modifying for structural integrity.

As part of this program, damage tolerance analysis primarily addresses the service life limits of airframes. When combined with other analyses like stress, loads, vibration, and flutter, DTA can help assure the continued structural integrity of Air Force aircraft. It is clearly one of the most important ways AFLC provides combat strength through logistics.

MAINTENANCE IN ACTION—



Maintenance personnel perform functional check of F-15 flight controls.

QA inspector checks F-15 speed brake.

Unscheduled Maintenance Dispatching: Simple and Effective Decision Rules*

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Introduction

When people use the term "maintenance scheduling," most of us probably think of the scheduling of routine preventive maintenance actions. When referring to *un*scheduled maintenance scheduling decisions, we typically use the term "dispatching." Yet both dispatching and preventive maintenance scheduling determine the order in which various tasks or jobs should be done. Therefore, both are a form of scheduling or sequencing. When the line chief decides which aircraft should be worked first by a given shop, when the shop chief decides which line replaceable unit (LRU) to repair first, and when the crew chief decides which tasks should be done first on the aircraft, each is making some kind of sequencing or dispatching decision.

Although managers have substantial written guidelines and even computer-based assistance when making *scheduled* maintenance decisions, very little help is available to them when making decisions about the best sequence for *unscheduled* maintenance actions when more than one alternative is possible. However, this lack of guidance should not be interpreted to mean that the problem is insignificant. In fact, it is not unusual for many aircraft, missile, and communications-electronics maintenance shops to spend more than half of their direct support man-hours responding to unscheduled maintenance demands. This article describes some simple and effective rules which managers can use to make more efficient use of the resources committed to unscheduled maintenance.

Unscheduled Maintenance Environment

Maintenance is defined as the set of activities necessary to retain a system in, or restore it to, a serviceable condition. (1:17) Unscheduled maintenance, then, consists of those maintenance actions which were not specifically foreseen or planned, typically in response to system failure. Unscheduled maintenance of complex systems frequently involves the coordinated activity of many people, each possessing some subset of the technical skills necessary to support the overall system. Even within a given specialty, maintenance technicians typically possess varying combinations of capabilities assigned to that specialty and varying skill levels within each of those task capabilities.

In addition to trained personnel, various tools, test equipment, support equipment (electricity, cooled air, compressed air, etc.), and spare parts may be required for each different maintenance action. While such requirements can be planned for, and accommodated, in advance for scheduled maintenance actions, they are rarely known with certainty in the unscheduled case. Therefore, the ability to complete each unscheduled maintenance job in a timely manner is typically constrained by the availability of one or more of the required skills, parts, or pieces of support equipment.

To make matters worse, the combination of unscheduled jobs which will arise at a given point in time is difficult to predict. In some cases, the pressing need is to perform many unscheduled maintenance tasks on a single critical system, such as an aircraft standing alert. In other cases, it may be necessary to produce a large number of aircraft by accomplishing many less complicated repairs on each aircraft. The nature of the needs is generally a function of the unit's mission and its current status.

If any generalization can be made about the unscheduled maintenance environment, it is that the demand is unpredictable (nature, frequency, and quantity) and that the demand is likely to exceed the required resources (qualified technicians, specialized equipment, and time). The end result is the need for the most efficient decisions possible in a highly complex decision-making environment.

The Traditional Approach

Given this complex problem, how can we expect maintenance managers to decide what should be done first? Of course, in some cases, the decisions are easy due to the technical constraints involved. For example, if an aircraft has problems with both its air-conditioning and radar systems, there may be no choice but to repair the air-conditioning system first since it will be needed to troubleshoot and repair the radar problem. Similarly, if each of the two shops has technicians available for work, but one requires a piece of support equipment which is unavailable, the decision may be obvious.

But in many cases, the decision is not so easy: there may be many alternative courses of action (sequences) available. In such instances, we typically rely on our experience in making the decision. For instance, the master sergeant with a maintenance background spanning two decades can usually be relied on to decide the order in which the various tasks should be done with amazingly good and consistent results. However, in many cases, the rules which guide this decision maker's behavior may seem so situation-specific that generalization to

* The author wishes to point out that the decision rules presented in this paper are easily implemented in simple computer code or in spreadsheet form. The examples used in this paper were constructed with the aid of such a spreadsheet, as implemented by Dr. Everette S. Gardner, Jr. An article by Dr. Gardner explaining how to construct the spreadsheet is forthcoming in a future issue of *Lotus* magazine. Readers without access to *Lotus* magazine are welcome to contact Major Jacob V. Simons, Jr., 10810 Telephone Rd., #342, Houston, TX 77075 to request a copy of the spreadsheet and/or instructions for its construction.

other maintenance contexts is virtually impossible. In some cases, the decision guidelines used by experienced managers may be so deeply ingrained that they even have difficulty verbalizing them in the first place. This leaves novice managers with little choice but to follow a trial-and-error approach to developing their own set of "rules."

Scholarly journals do little to fill this void. Unfortunately, the literature concerning maintenance scheduling has been largely devoted to preventive actions rather than unscheduled maintenance response. Although it is impossible to explain this tendency with complete certainty, it is likely that the complexities described have been perceived as preventing the rigorous mathematical modeling which facilitates optimal solution techniques. The varieties of unscheduled maintenance demands and the multiplicity of potential objective functions (goals) mean that any *realistic* quantitative approach to the unscheduled maintenance problem is typically reduced to a complex queuing analysis, requiring the use of very intricate waiting line theory coupled with computer simulation. Although such analyses are helpful in many cases, the peculiarities and assumptions built into simulations frequently prevent broad generalization of their results. In addition, the average decision makers are typically not in a position to reproduce or tailor the results of such studies by generating simulations of their own operations.

Simplifying the Problem

A simple analysis of the varying situations would suggest that, in many cases, it may be unnecessary to consider *all* the complicated aspects of the real-life problem. Instead, it may be sufficient to reduce the problem to its most constraining essential conflict and then solve this simpler problem. In other words, first identify the primary dilemma and temporarily ignore the other aspects of the problem. Recent evidence indicates this may well be the approach used in practice by experienced schedulers. (5:84-90) Additional support for this approach can be seen in Eli Goldratt's Optimized Production Technology (OPT) approach to production scheduling. (3:209) One of the key underlying principles of OPT is that the rate of production is determined by bottlenecks. Time saved at any point *other* than a bottleneck is simply an illusion: the bottleneck still controls the overall rate of flow. In the context of maintenance sequencing, it does no good to finish one task earlier if accomplishment of your overall objective is still constrained by the completion of other tasks. Therefore, it may be possible to make better dispatching decisions by simplifying the unscheduled maintenance problem to that of managing the most critical (or constrained) resource. (This may be perceived as roughly similar to managing the critical path activities in a Critical Path Method (CPM) project network.)

The unscheduled maintenance environment can frequently be simplified in a variety of ways. As described earlier, the maintenance manager may be concerned primarily with the completion of all maintenance tasks on a single, important aircraft. Conversely, a manager may have a single shop whose technicians are needed to repair many different aircraft (or LRUs). Finally, a manager may simply not have enough time to accomplish all required jobs on time. Later on, I will explain how each of these simplified problems can be solved easily using simple decision rules.

Single Machine Scheduling

A substantial amount of academic research has been compiled dealing with the best way in which to schedule a set of n jobs through m processes or machines. (2) The simplest case of these scheduling problems occurs when m=1, referred to as single machine scheduling. Many rules have been shown to produce optimal results for different objective functions (goals or performance measures) in the single machine case. These rules have been helpful both for direct use in applications which can be reasonably approximated as single machine problems *and* as building blocks for more complex problem situations. In the remainder of this paper, we describe three of those simple rules and explain how they can be applied to the unscheduled maintenance problems previously mentioned.

Different Rules for Different Goals

Minimizing Average Completion Time

First, consider a situation in which, at midnight following a night flying schedule, seven aircraft have returned with malfunctions in their electrical systems. Assume that the Electric Shop will have only one crew available for dispatch on each shift until the aircraft are scheduled to fly again the following evening. Also, assume that other work must be accomplished on each aircraft, but that much of that work cannot be completed until the Electric Shop has repaired each aircraft. Therefore, we might simplify this problem by characterizing it as a single machine scheduling problem in which each of the seven aircraft constitutes a job to be completed (n=7) and the Electric Shop represents the single "machine" (m=1). Finally, assume that our objective is to minimize the average completion time of the Electric Shop on each aircraft and that the shop has provided the initial troubleshooting and repair time estimates shown in Table 1 based on the aircrew's description of the malfunction given during debriefing.

Aircraft Job	*Estimated Hours*
Aircraft A	2
Aircraft B	5
Aircraft C	1
Aircraft D	8
Aircraft E	4
Aircraft F	3
Aircraft G	9

Table 1: Jobs and Repair Time Estimates for Electric Shop.

Before describing the appropriate decision rule, some observations are in order:

(1) The simplified problem description and objective are appropriate if few jobs have been identified for other shops or if the other shops have proportionately more crews available for dispatch. In either case, the manager has substantially greater flexibility in dispatching the other shops, and the Electric Shop is the true "bottleneck" in determining the average completion time of maintenance on each aircraft.

(2) The overall time required for the Electric Shop to complete all seven jobs (referred to in the academic literature as makespan) is always 32 hours regardless of the sequence in which the aircraft are worked. However, the *mean* (average)

completion time at each aircraft may vary substantially, depending on the sequence in which the shop is dispatched (Table 2). Clearly, the higher the mean completion time, the greater the average delay for work on subsequent aircraft.

Schedule	Average Job Completion Time
A,B,C,D,E,F,G	13.4
B,C,D,E,F,G,A	15.4
C,D,E,F,G,A,B	15.1
D,E,F,G,A,B,C	17.3
E,F,G,A,B,C,D	15.4
F,G,A,B,C,D,E	16.3
G,A,B,C,D,E,F	17.3

Table 2: Average Completion Times for Various Schedules.

The single shop scheduling rule which minimizes the average completion (or "flow") time is called the Shortest Processing Time (SPT) rule. (4:61-68) *The SPT rule determines the schedule by simply sequencing the jobs in ascending order by their processing times,* i.e., the job with the shortest processing time is scheduled to be worked on first, and so on until the one with the highest time is scheduled last. The SPT schedule for our example is shown in Figure 1. It can be guaranteed that no other sequence will produce a lower average completion time (although on other problems there may be other schedules with an equally good average completion time).

```
Aircraft In Work                  Time

    C    C
    A     AA
    F       FFF
    E          EEEE
    B              BBBBB
    D                   DDDDDDDD
    G                           GGGGGGGGG
         0-------------------------------32
         Average Completion Time = 11.0 hours
```

Figure 1: Gantt Chart for Shortest Processing Time Schedule.

Note that:

(1) The single machine example shown is also applicable to the case of a single piece of support equipment which is needed by many shops. Likewise, this case also covers the repair of a single aircraft by many shops. Although the overall time required to complete the single aircraft remains the same, the SPT rule will enable more shops to finish their portion earlier than with any other decision rule.

(2) Even though the SPT rule is simple, this does not imply that the problem itself is simplistic. In order to find the best schedule by considering all possible alternatives, 5040 schedules (7x6x5x4x3x2x1) would need to be evaluated.

(3) For the single machine case, SPT also minimizes mean waiting time, mean lateness, and mean work-in-progress inventory.

Minimizing Maximum Tardiness

Continuing with the example, let us now assume that the job at each aircraft has been given a deadline (due time) to facilitate subsequent sorties. These due times are shown in Table 3. If work is assumed to begin at midnight (0000 hours), it is clear that some jobs may have to be late. If, as before, we apply the SPT rule, we have the results shown in Table 4. Since SPT bases its decision solely on processing times and completely ignores due times, we may obtain a schedule where at least one job (Job G) is unacceptably tardy. We may consider it better for more aircraft to be a little late than for any one aircraft to be *very* late.

Aircraft Job	Estimated Hours	Due Time
Aircraft A	2	1200
Aircraft B	5	2100
Aircraft C	1	1500
Aircraft D	8	1700
Aircraft E	4	2300
Aircraft F	3	2000
Aircraft G	9	1200

Table 3: Repair Estimates and Due Times For Electric Shop Jobs.

SPT Schedule	Hours Late	EDD Schedule	Hours Late
C	−15	A	−11
A	−10	G	2
F	−13	C	0
E	−12	D	1
B	−7	F	−2
D	1	B	−3
G	6	E	−5
Max. tardiness (G): 6		Max. tardiness (G): 2	

Table 4: Minimizing Maximum Tardiness.

An alternative to SPT which achieves this objective by minimizing the maximum tardiness of any single job is the Earliest Due Date (EDD) rule. (2) *EDD simply sequences jobs by dispatching the shop to the aircraft with the earliest remaining due time, regardless* of the estimated processing time. For our example, the EDD solution is shown in Table 4. Note that such a rule might be appropriate when aircraft are scheduled to fly in blocks or flights. In such situations it may be permissible to delay all aircraft in the same flight for a short period; but, if any one aircraft is delayed *too* long, the entire flight may have to be canceled.

Minimizing the Number of Late Jobs

Finally, assume that a series of equally important major events will occur at predetermined times. Only those aircraft whose repairs have been completed will be able to participate. Consequently, the principal scheduling objective becomes the minimization of the *number* of late jobs (aircraft which are not ready for launch).

The single machine rule which achieves this objective is called Moore's rule in honor of its originator. (6:102-109) Moore's rule is basically an iterative two-step procedure. *In the first step, all jobs are sequenced according to the EDD rule. In the second step, the resulting sequence is reviewed starting with the first scheduled job. If a job is encountered which would be late, the job with the longest processing time up to that point in the schedule is placed at the end of the sequence. This second step is repeated until any remaining late jobs have been resequenced once.* Beginning with the EDD schedule in our example (Table 4), the first late job is G. Since G has the longest processing time of either G or A (9 versus 2), job G is shifted to the end of the schedule. In this example there are no other late jobs now, so Moore's procedure is finished. The resulting schedule is shown in Table 5 and is compared with those produced using the SPT and EDD rules. Clearly, this rule achieved the desired minimization of the number of late jobs.

SPT	Hours Late	EDD	Hours Late	Moore's Rule	Hours Late
C	−15	A	−11	A	−11
A	−10	G	2	C	−13
F	−13	C	0	D	−3
E	−12	D	1	F	−2
B	−7	F	−2	B	−3
D	1	B	−3	E	−5
G	6	E	−5	G	6
Late jobs: 2 (D,G)		Late jobs: 2 (G,D)		Late jobs: 1 (G)	

Table 5: Minimizing the Number of Late Jobs.

Conclusion

We have presented three simple decision rules which produce theoretically optimal dispatching decisions. These rules would be useful when the existence of dominating constraints in an unscheduled maintenance environment permits simplification to an analogous single machine scheduling problem. The three situations and their corresponding rules are shown in Table 6.

We should point out that, while these rules can be shown to be mathematically optimal, their effectiveness in practice depends on how well the actual problem matches the simplified assumptions *and* on the quality of the repair time estimates. Although the estimates need not be perfect for the chosen schedule to be best, they should at least be accurate in terms of their proportion, relative to each other. In fact, it is in regard to time estimates that more experienced maintenance managers excel. They recognize, for example, that repair time estimates must include the time required for tool/tech order checkout, transportation, setup, and any other delays likely to be encountered—not just hands-on repair time. We hope that these decision rules will help both novice and experienced managers in cases where true estimates are available or can be determined with reasonable accuracy.

Goal	Rule
Minimize average job completion time	Shortest Processing Time
Minimize the maximum job tardiness	Earliest Due Date
Minimize the number of late jobs	Moore's Rule

Table 6: Summary of Decision Rules.

(Major Simons is presently a student at the Univ of Houston pursuing a degree under sponsorship of AFIT.)

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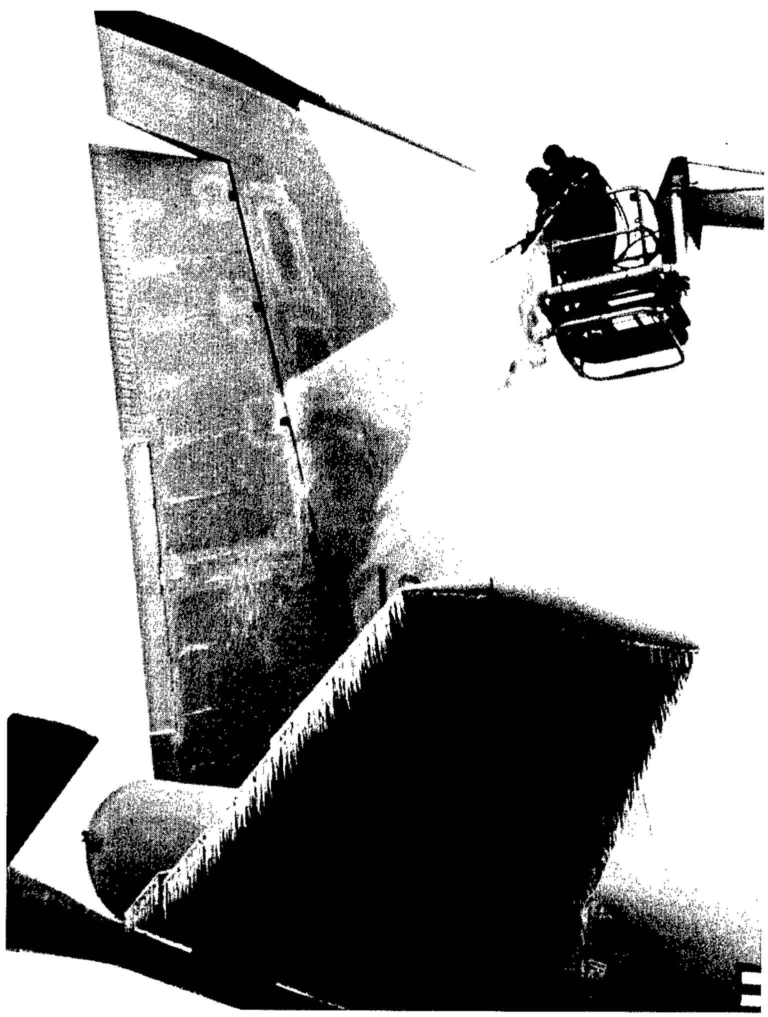
DE-ICING AN AIRCRAFT



CAREER AND PERSONNEL INFORMATION

Civilian Career Management

LCCEP Training and the Logistician

In addition to providing a source for Air Force-wide competition to fill key civilian logistics positions, the Logistics Civilian Career Enhancement Program (LCCEP) emphasizes training and development opportunities for members of its Executive Cadre and for high potential registrants.

During each Cadre member's tenure, at least one short-term training course is provided to enhance career progression. A series of short-term, on-site courses have been arranged for sites with a high density population of LCCEP registrants. Although these courses are specifically designated for Executive Cadre members, slots that are not used by Cadre members are then given to high potential LCCEP registrants. The short-term courses for FY90 are:

- Building an Effective Logistics Team (BNA)
- Responsible Logistics Management (BNB)
- The Logistics of Managing Conflict (BNC)
- Situational Management—A Corporation Exercise (BND)
- Managing Logistics in the Federal Sector (BNF)
- Technological Developments and Management Impact (BNE)
- Developing Leadership and Teamwork Excellence (Stylemetrics) (BQQ)
- Communicating and Counseling (CCD)
- Information Engineering (OJC)

Quotas for these courses are allocated through the local Central Civilian Personnel Office (CCPO) with the supervisors' concurrence. All LCCEP registrants should discuss their preferences for these courses with their supervisors first. Then, with their concurrence, they should indicate these preferences on their Career Enhancement Plan (CEP) using the 3-digit codes previously listed. The CEP is available through the servicing CCPO.

Graduate Level Training opportunities are also available at the Air Force Institute of Technology (AFIT), the University of Texas at Tyler, and at various civilian institutions. The AFIT Graduate Logistics Management Training is an intensive 15-month program at Wright-Patterson AFB, Ohio. The fields of study offered by AFIT through LCCEP are: Logistics Management, Transportation Management, Maintenance Management, and Systems Management. Limited PCS or TDY to Wright-Patterson AFB and back to home station is funded by AFIT. Nominations are requested during November of each year, and packages are due to the LCCEP Program Office in February.

Beginning in the Fall of 1989, the career program will sponsor training at the University of Texas at Tyler. Course study will lead to a Master of Science Degree in Industrial Distribution/Logistics. The unique curriculum will require the participant to attend four, 4-week resident sessions at the university for a period of two years. The student will spend the remainder of the semesters at his/her home station completing course projects. This program allows the "best of both worlds" by letting the student attend university courses with only a minimum of absences from the job. The first message asking for nomination packages for this new program went out in December 1988. All packages were due to the Program Office by 1 April 1989.

The Civilian Institutions Graduate Level Logistics Management Training is a 12-month program that begins in August/September at various civilian institutions of higher learning. Graduate education must be related to the logistics career field. Nomination packages are requested in January of each year. Packages are due to the LCCEP Program Office around the first week in April.

The Undergraduate Level (upper division) Training provides up to twelve months' upper division logistics management related training at a civilian institution. Candidates must have completed 90 semester hours in an undergraduate program. Nomination packages should identify the specific training required and the need for training. Packages should also include a post-training utilization plan identifying specific benefits this training will provide the Air Force. Announcement times and nomination deadlines are the same as for the Civilian Institutions Graduate Level program.

LCCEP also sponsors nominations for Professional Military Education (PME) courses. The Air Force recently received increased allocations for the PME courses, allowing civilians greater opportunities to participate in programs which previously had limited or nonexistent civilian participation. The PME courses are:

Name	*Course Code*	*Min Grade*
Air War College	ACR	GS/M-14
National War College	ACT	GS/M-14
Industrial College of the Armed Forces	ACU	GS/M-14
Armed Forces Staff College	AC2	GS-12
Air Command and Staff College	ACS	GS-11
Squadron Officer School	B99	GS-09

Each June the requests for nomination packages are sent to the training section in the CCPOs and to senior management within the logistics community.

LCCEP's Career Broadening Program provides Air Force-wide opportunities for individuals and managers to gain intercommand experience. Career broadening positions are filled through an LCCEP panel process that reviews proposed broadening assignments for Cadre members and other high potential LCCEP registrants. These assignments are planned for a 24-month period and allow the participants to gain "hands on" knowledge of a different aspect of logistics than previously experienced. Both the Air Force and the individuals can benefit from this assignment. The organizations hosting the career broadeners enjoy the experience the individual brings to that office, while broadeners will be able to apply knowledge gained to their planned post-broadening assignment. Nominations for LCCEP Career Broadening are requested twice a year, usually in January and July. Packages are due to LCCEP in March and September of each year.

The Education with Industry (EWI) program provides participants with on-the-job training and experience with civilian industry. For ten months, the EWI selectee is integrated within the company's functional infrastructure and receives insight into the company's various operations. Nominations are requested in August of each year and packages are due to AFCPMC/DPCML in November.

The Office of Assistant Secretary of Defense (OASD) Professional Enhancement Program offers the opportunity to gain insight into OASD operations and Congressional activity. This is a one-year program designed to enhance the development of selected mid-level

management personnel working in supply, transportation, maintenance, and the international logistics career fields. Nominations are requested in December of each year and actual packages are due to LCCEP in March.

The OPM Executive Seminar Center (ESC) Program consists of several two-week residential seminars designed to meet varied training needs of government managers and executives. If LCCEP registrants wish to be considered for EDC courses in FY90, they must enter their requirements on their Career Enhancement Plan (CEP). Each base differs on the time for submitting the CEP requirements, so registrants should check with their organization training monitors or the training office in their servicing CCPO. The most popular seminars for LCCEP people are:

Seminar	*Course Code*	*Min Grade*
Science, Technology, and Public Policy	AAI	GS/M-13
Presidential Initiatives for Federal Productivity Improvement	AAX	GS/M-13
Role of Government in Technology Transfer	AAW	GS/M-14

Other courses available through ESC are:

Seminar	*Course Code*	*Min Grade*
Executive Development Seminar	AAM	GM-15
United States Foreign Policy	AAP	GS/M-14
National Security Policy	AAQ	GS/M-14
Federal Personnel Management Issues	AAR	GS/M-14
Current Issues Seminar	AAT	GS/M-14
Managerial Competencies for Executives	AAU	GS/M-14
Seminar for New Managers	AAA	GS/M-13
Federal Program Management	AAC	GS/M-13
Administration of Public Policy	AAD	GS/M-13
Economics and Public Policy	AAE	GS/M-13
Management Development Seminar	AAL	GS/M-13

Additionally, the LCCEP endorses nominees for the Harvard University's Education for Public Management, Princeton University's Education Program for Federal Officials at Mid-Career, and the LEGIS Fellows Program. Final selection for these programs is made by an Air Force board which considers inputs from all career programs and non-career program covered candidates.

Indeed, the LCCEP offers unique training opportunities to its registrants. However, to be considered by management for any of these opportunities, logisticians must be registered in the LCCEP. Those personnel not currently registered should complete an AF Form 2675, Civilian Career Program Registration and Geographic Availability, and submit it to their servicing CCPO. For more information on any of the LCCEP Career Development programs, please call AUTOVON 487-5352.

(Rita Fox, AFCPMC/DPCMLD, Randolph AFB TX 78150-6421, AV 487-4631)

READER EXCHANGE

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More About Combat Support Doctrine

Having been the Air Staff action officer responsible for the publication of AFM 1-10, *Combat Support Doctrine*, I would offer the following opinions:

(1) The manual is balanced in describing those logistical preparations that precede combat. If anything, it does not give adequate weight to the PPBS, acquisition, and training processes that drive our force structure and its capacity to deter and fight.

(2) The term *combat support* should be replaced by the word *logistics* in the title and throughout the manual. However, the Air Force was not and is not ready to accept *logistics* as the generic descriptor of all Air Force support functions. However, combat support is the final purpose for all military logistics and each logistic function must appreciate this fact no matter how far removed—in time and space—from combat.

(3) A section needs to be added that describes the echelons of command—the strategic, operational, and tactical levels—and the role of each echelon in the logistics processes.

(4) The combat support principles need expansion/revision to provide greater insight into the fundamental nature of logistics.

(5) Finally, what is far more important than revising AFM 1-10 is the formulation and publication of functional doctrine. (Only the civil engineers seem to grasp the importance of codifying and inculcating their people with the basic tenets of their profession.)

In sum, doctrine is not immutable but any changes to AFM 1-10 should be well thought out. Those who helped fashion it did so after extensive research and seemingly interminable coordination. Therefore, those who would change our basic doctrine must have a clear objective of where it is they want to take us.

Colonel William T. McDaniel, Jr., USAF
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Most Significant Article Award for 1988

The Editorial Advisory Board has selected "Some Thoughts on Combat Support Doctrine (AFM 1-10)" by Major Michael C. Green, USAF, as the most significant article published in the *Air Force Journal of Logistics* during 1988.

Stock Control and Distribution (SC&D): The Benefits of an Integrated Database System

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Introduction

The need for faster, more accurate movement of supplies and equipment to our combat forces has never been as important as it is now. The Air Force is faced with a stringent budget which has mandated a reduced force structure. The only way to maintain a comparable level of combat capability is to make efficient use of the aircraft we support. The Logistics Management System (LMS) will play a role in Air Force posturing for many years to come. With the LMS, the Air Force Logistics Command (AFLC) is making major changes in its ability to acquire, allocate, and distribute the limited supplies and equipment needed to keep combat systems operational.

The foundation of the LMS effort is the Stock Control and Distribution (SC&D) program. This system is designed to process base requests for supply support in minutes and hours versus days and weeks. The Air Force Audit Agency has validated SC&D benefit projections and stated that the improved support is equivalent to adding 103 aircraft to the Air Force's inventory. More recent studies by independent contractors have indicated SC&D projected savings will have far greater impact than originally anticipated. This paper provides an overview of the SC&D program, the integrated database techniques used to design the system, and the resulting benefits.

First Phase of SC&D Implementation

Because of the size and complexity of the total SC&D program, it was divided into smaller segments, called subsystems or Computer Program Configuration Items (CPCIs). Subsystem 1 is the Item Manager Wholesale Requisition Process. This subsystem required the equivalent of approximately 400,000 lines of computer coding and involved more than 200 interfaces with other computer processes. It provides item managers (IMs) with on-line processing capability and almost instantaneous visibility of inventory balances. The remaining subsystems deal mostly with distribution functions which include air terminal management and operations, receiving and shipping operations, and inventory processes, and the transportation management functions which include movement of cargo and passengers worldwide. Figure 1 presents the new subsystems and the

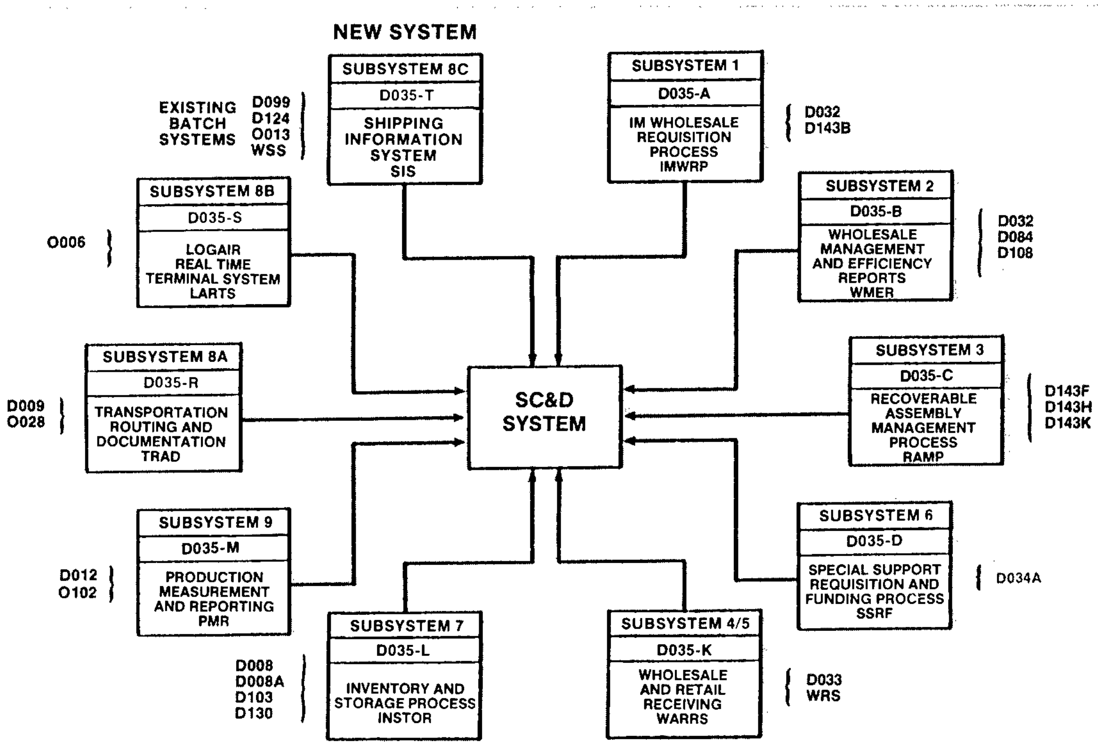

Figure 1: SC&D Subsystem Identification.

existing batch systems they encompass. The new subsystems are in the blocks.

Subsystem 1

This new system was initially implemented at Oklahoma City Air Logistics Center (OK-ALC) on 19 July 1987 and is now implemented at all ALCs. Here is how it works:

a. Requests for Air Force managed parts and equipment are submitted by phone, by mail, or electronically through computers over a complex network of communications systems to the ALC responsible for managing the item. Most of these requisitions are processed electronically in seconds without the need of human intervention. Those requiring special handling or other decisions are routed directly to the IM. This is done through a local area network (LAN) which ties the SC&D computer (which received the request) to hundreds of smaller computers where each IM can immediately decide what actions are necessary.

b. The IM has visibility of inventories locally and those reported by other Air Force bases using data recorded in the SC&D computer. The IM decides whether to backorder the item or provide support from existing inventories. For selected critical items, the IM elects to withhold support of routine requisitions and to support only the most critical requirements. Once a decision is made, the IM provides instruction from a number of options reflected on the computer terminal. These instructions direct the larger SC&D computer to continue processing the request. If the item is available for shipment, the computer immediately initiates shipping actions and provides electronic notification (status) to the base/customer requesting the item. If the item is not available, the computer notifies the customer and automatically takes actions to backorder the item. All is done in a matter of minutes.

Under the previous batch system, requisitions were processed once or twice a day. If the requisition required IM action, the IM would receive a listing from the latest processing cycle (usually from the previous day) and then use the prior day's records to determine what actions to take. Decisions were made and later reinput for processing on the next requisition processing cycle. Assuming no erroneous data, the requisition processing continued.

If there were errors, the requisition would continue to be recycled until all input data was correct and the system could finish processing the decisions. Sometimes the process took days and the requisitioner had no feedback until the requirement finally processed correctly.

It is not difficult to see the tremendous benefits the IM has received with the implementation of SC&D. These benefits will further increase as the system is refined and the remaining SC&D subsystems are brought on-line. Customers at Air Force bases worldwide also have been affected dramatically by the implementation of SC&D's first subsystem. Some parts are arriving at the base from one to three days earlier than was possible before. In addition, the availability of current asset data allows the bases to make better informed decisions that will result in increased aircraft availability. For example, bases now are able to preclude taking parts off one aircraft to satisfy a demand on another aircraft because base personnel know an asset is on its way.

Subsystem 8B

Next to be implemented is the LOGAIR Real Time Terminal System. This subsystem provides for automated in-checking, staging, visibility, palletization, manifest documentation, and reporting for air cargo moving through the five ALCs and Wright-Patterson Air Force Base, Ohio. This subsystem will take what was previously a batch system with some manual operations and convert it into a totally automated, on-line, interactive system for the (1) due-in/on-hand cargo visibility, (2) in-checking and staging of cargo, and (3) cargo and shipment documentation.

The new system will be provided advance notice of aircraft arrival, pallets to be offloaded, and space allocation for the ALC's use in staging cargo. The computer will use the space allocation to select the highest priority cargo for shipment if it falls within the weight and cube limits of the allocation. The warehouse will receive documentation of property to be selected and packaged for shipment. Upon arrival at the air terminal, the outbound property will be palletized. The computer will provide all necessary shipping documentation and notify the down-line stations of the cargo loads for their destination. The computer will also assist in the cargo off-load and advise where property is to be staged for further movements on other transiting flights or delivery to on-base activities through other SC&D processes (Subsystem 4).

Air terminal personnel will be able to communicate with the computer using radio frequency portable input terminals (RFPITs) from aircraft staging spots which are often a considerable distance from the air terminal. In the past, workers had to handscribe data and carry it to and from the air terminal computer center, obviously a time-consuming and wasteful use of limited personnel. The end result will be faster, more accurate movement of property, better control and visibility of what property is in the terminal and where it is located, better transfer of data to down-line stations, and the elimination of old teletype terminals and use of cards and card punch equipment.

Subsystem 4/5

As soon as the air terminal subsystem is in place, we begin the next implementation. The Wholesale and Retail Receiving Support process is a very complex, diverse subsystem.

This subsystem processes receipts from contractors and other suppliers (including other military facilities) and turn-ins of property from maintenance and other on-base activities. It also directs the movement of property into and out of storage and keeps track of where the property is located during these processes. Additionally, it computes requirements and processes retail customer requests and related transactions in support of ALC maintenance activities. This subsystem maintains the official stock number accountable records and ensures audit trails are provided. It will provide a new feature whereby items received will be processed automatically and dispersed (after inspection) to the warehouse or shipping areas to satisfy an existing requirement. The Inventory and Storage Process subsystem (Subsystem 7) accomplishes random sample inventories and reçonciles the records with physical balances and warehouse locations. This subsystem will be incremented concurrently with Subsystem 4/5.

Subsystems 8A and 8C

Next are the other transportation management subsystems (Transportation Routing and Documentation and Shipping Information System). These systems consist of shipment planning, shipment packing, preservation and packaging, and surface terminal operations.

The shipment planning subsystem coordinates requisition processing through the warehouse, packing, surface terminal,

and air terminal, and provides for efficient preparation of shipments for movement. It even provides for automated selection of the mode of transportation and identifies which carrier to use. Over 90% of the shipments are planned by the computer. Materiel planned for off-base movement is routed through the packing function where packing protection is applied based upon the mode of transportation assigned by shipment planning. Preservation and packaging properly protects items during storage and ensures the use of approved quantity unit pack for issue. The surface terminal operation is responsible for loading and unloading commercial and military motor carriers and rail cars, preparing required shipping documentation, safeguarding and maintaining control of materiel in the terminal, and transferring inbound air cargo to surface modes for further movement.

Many of these functions were performed manually and were very labor-intensive efforts. Because of the complexity of these processes, the potential for human error was substantial.

Other Subsystems

Other subsystems, Wholesale Management and Efficiency Reports (Subsystem 2), Recoverable Assembly Management Process (Subsystem 3), Special Support Requisition and Funding Process (Subsystem 6), and Production Measurement and Reporting (Subsystem 9) are management reporting oriented subsystems.

SC&D Benefits

The Air Force will benefit tremendously through the mechanization of manual workloads and the introduction of advanced technologies into all major areas of distribution. Figures 2 and 3 provide a graphic comparison of the old and new systems.

- The on-line interchange of data between subsystems allows the Air Force to maintain visibility of items through the entire depot processing cycle. This capability enables the Air Force to issue items directly from central receiving and preservation and packaging without first moving the item to storage. Cancellations, diversions, and replans can be accomplished immediately at each location throughout the processing cycle. In addition, new routing, mode of transportation, or shipping documentation can be mechanically prepared and output at the appropriate computer terminal.
- The application of bar code technology within the SC&D system provides the capability to in-check and out-check materiel, perform inventories, reconcile inventories with computer balances, consolidate shipments, and prepare numerous types of shipping documentation automatically without the arduous task of manually entering and recording lengthy strings of data. This not only reduces the effort of entering the data but also eliminates data entry errors.
- The capability to release backorders immediately, as receipts are processed, will reduce binning actions and provide assets to the Air Force bases or depot maintenance one to three days faster. Customers will be notified within minutes of depot actions to satisfy their latest requirements.
- The capability to interrogate shipment data will have the same effect on the customer as the initial subsystem. We will now be able to trace shipments and provide current status on a real-time basis. The on-line file maintenance capability will ensure that shipping decisions are made based upon the latest possible information, thus reducing shipping errors and making better use of transportation funds.
- Mechanically prepared documentation such as shipment change data, notices of availability, and reships will reduce the manual workload and potential for errors, as well as improve the timeliness of the data. The system will even tell the shipping clerks the packaging and preservation requirements specially tailored to each item which will reduce loss due to damage or decay.
- The complete mechanization of the surface terminal from manual operation will have significant benefits. The capability to cancel, divert, or replace shipments will not only make better use of transportation dollars but will ensure the right part gets to the customer in the least amount of time.
- The inventory and audit trail process will be enhanced by the visibility of assets throughout distribution, thus improving the use of buy and repair dollars.
- The specific benefit of the SC&D program is the enhancement of Air Force readiness through better logistics support. This support will be significantly improved by:

a. Processing customer requisitions faster through the allocation and movement functions at the ALCs, thereby reducing order and shipping times (O&ST). The shortening of O&ST will reduce the amount of time grounded aircraft must wait for a part (not mission capable supply (NMCS) time). Also, in some instances, the shorter O&ST will put parts at the base sooner to prevent aircraft from even going into an NMCS condition.

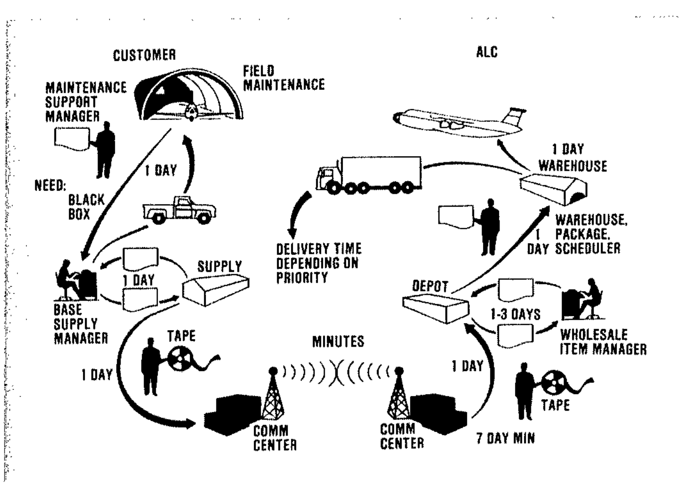

Figure 2: Before SC&D Implementation.

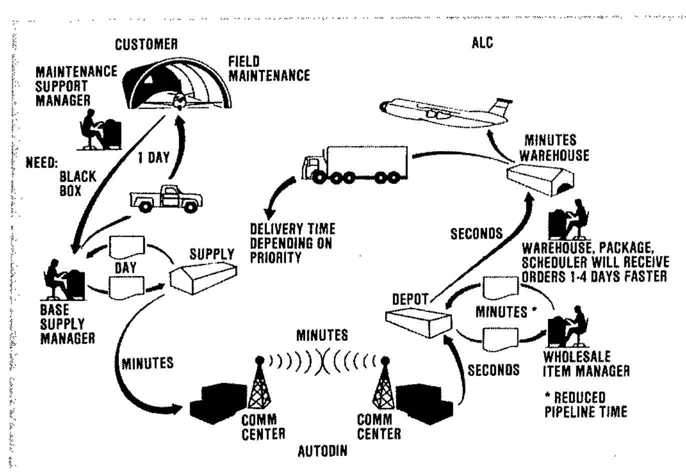

Figure 3: After SC&D Implementation.

b. Providing more current information on local asset receipts, base-level asset posture, etc., thereby permitting the allocation decision to be made earlier and O&ST to be shortened.

c. Providing the retail customers current supply and transportation status, thereby enabling them to make alternate support decisions—such as cannibalization or lateral support actions—quickly.

d. Enabling an initial allocation decision to be made more quickly. Prior to today's environment, the ALCs ran their wholesale allocation and movement computer routines on a cyclic basis—once or twice a day. New requisitions received could wait up to 24 hours for the next computer cycle to start.

The series of wholesale allocation and movement batch computer programs takes 6 to 9 hours run time from start-up to printing of the shipping tickets. Under the old environment the production of a shipping ticket could take from 6 to 33 hours after receipt of the requisition at an ALC.

An on-line, transaction-driven system has the capability to make an initial allocation decision (fill or backorder) within 5 seconds after input into the system. The materiel release order (MRO) would then be transmitted immediately to the collocated or off-base storage and distribution point (SDP) stocking the materiel.

Thus, the SC&D systems have the potential to save up to 33 hours in processing time for creation and transmittal of the MRO due solely to modern hardware, software, and communications routines.

e. Allowing IMs to clear exceptions in a matter of minutes. A significant problem area in the past environment was the processing of exceptions due to failure of the requisition to pass edit checks or situations where the IM has coded the items for manager review. Exceptions were output in hardcopy and required manual decisions and corrections; then the requisition was reinput for subsequent processing in the next cycle computer run. If everything went smoothly, only one day of processing time was lost. SC&D's on-line, transaction-driven system gives the IMs the capability to clear exceptions in a matter of minutes and not lose processing time awaiting the next computer cycle.

f. Reducing communication time between sites. IMs have materiel stored at the prime site, collocated SDPs, and various off-base, non-collocated SDPs. If the allocation decision is to ship from a non-collocated SDP, about 50% of all MROs currently require two or more days of system interface time to go from the IM computer system, over the automatic digital network (AUTODIN), and be input into the next cyclic computer run at the off-base SDP. An on-line system at the IM and SDP sites would considerably reduce this time. If AUTODIN were used, this interface would be made in 15 to 120 minutes. If defense data network were used, the interface would be done in about 30 seconds. Thus, days can be saved.

g. Reducing processing times from the old systems to SC&D. These reductions are requisition/shipment (from 72 to 48 hours), requisition/ follow-up status (from 48 to 24 hours), local receipt data (from 12-24 to 4-16 hours), exceptions from time generated until corrected (from 72 to 48 hours), backorder releases (from 72 to 48 hours), and shipment confirmations (from 48 to 24 hours).

Advantages of Designing an Integrated Database System

The 23 batch systems that SC&D is modernizing were all designed using classical flat files for their data access. This batch technique effectively supported the file processing system of merging tapes, creating new tapes, and producing reports.

As additional functions and processes were added, the result was data being duplicated in a large number of the flat files. For instance a data element as basic as stock number was duplicated hundreds of times in the master files for the 23 batch systems. The requirement to develop an integrated SC&D system resulted in the use of an integrated database system. The database not only had to combine 23 batch systems but also had to support the 9 subsystems of SC&D.

Each subsystem has incremental phases of design, development, test, and implementation philosophy. If the database is not stable for all phases, it will require major modifications of existing software programs each time a new subsystem is implemented.

The engineering approach chosen for SC&D was a "data driven" design that combined database engineering with Computer Sciences Corporation's (CSC) own Digital System Development Methodology (DSDM). DSDM defines a software engineering discipline for system development and integrates management and technical functions to ensure that progress is measurable throughout the development process.

By following the "data driven" approach, the nine SC&D subsystems could be implemented in a time-phased manner and result in one fully integrated SC&D system. The five major database design steps are enterprise modeling, conceptual database design, logical database design, physical database design, and tuning. Figure 4 shows that to maintain integrity of the entire SC&D database design, it is necessary to review and integrate continually throughout all database design steps.

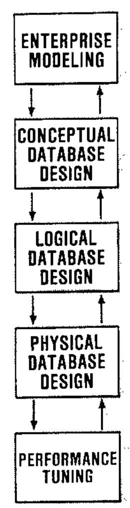

Figure 4: Phases of SC&D Database Integration.

Enterprise Modeling—The Analysis of Activities and Entities

The enterprise model describes what key areas, tasks, and activities make up the scope of the design effort and identifies the entities (data) that relate to those activities. The activities are mapped against the entities, and an analysis of how the

activities react with the entities is performed. For the SC&D system the enterprise model was developed from the SC&D Master Functional Description (MFD), the SC&D contract, analysis of existing systems and data, and interviews with functional experts.

The activities broke down into five major areas of interest: allocation, movement, custody, production management, and central site operations. Hundreds of activities were below the five major areas. Entities (data) broke down into six major areas: organizations, item management, documents, assets, location, and transportation. Each major entity had many subgroups below it. Figure 5 shows how the mapping took place.

Descriptions of how each detailed SC&D function and process is performed were not considered during this analysis phase. How such SC&D functions are or might be performed is a proper focus for program development, but does not enter into the database design at the enterprise model level. How a function is performed may change frequently, while the number of functions may remain stable over time. Thus, a database design based on the enterprise model is a stable representation of the inherent structure of SC&D data and will effectively and efficiently support any manner of performing a particular SC&D function.

There is one enterprise model for SC&D, and the original one developed for SC&D has required only minor modification as more knowledge is gained. This has allowed the development of new subsystems to be accomplished in an environment where a stable data platform supports the addition of new software programs.

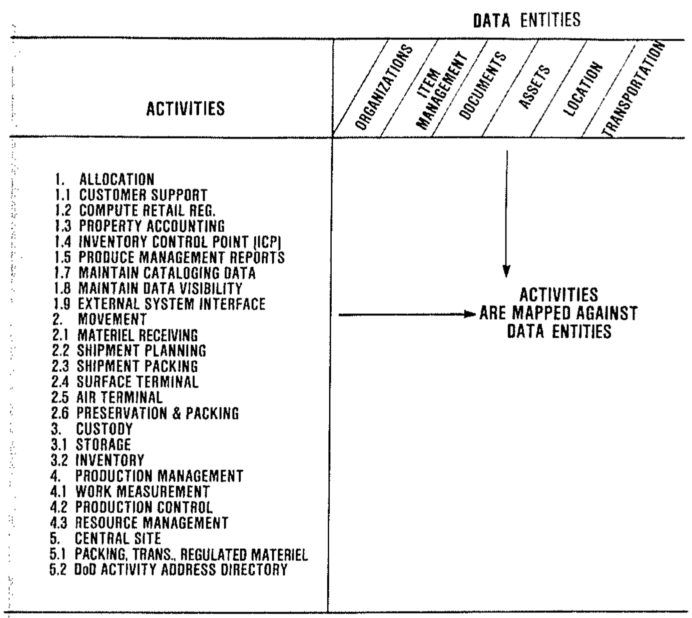

Figure 5: Enterprise Modeling Analysis.

Conceptual Database Design

The next step was the development of the SC&D conceptual data model. The model provides greater detail and presents the relationships of the entities (data) in a graphic form. An entity may be viewed as the focal point about which data may be clustered. Examples of entities are organization, IMs, items, requisition, usage data, and retail backorders.

The source of the greater detail is an analysis of the activities from the enterprise model and a detailed analysis of the current system's data requirements. The complete description must include any attributes associated with entities. Attributes are characteristics or descriptions of entities and usually link or describe relationships between entities. For example the entity "items" may have attributes such as reports, managers, or repairs. Figure 6 presents a portion of the actual model. The three tasks of adding identifiers, adding attributes, and normalizing the resultant structure were performed on SC&D.

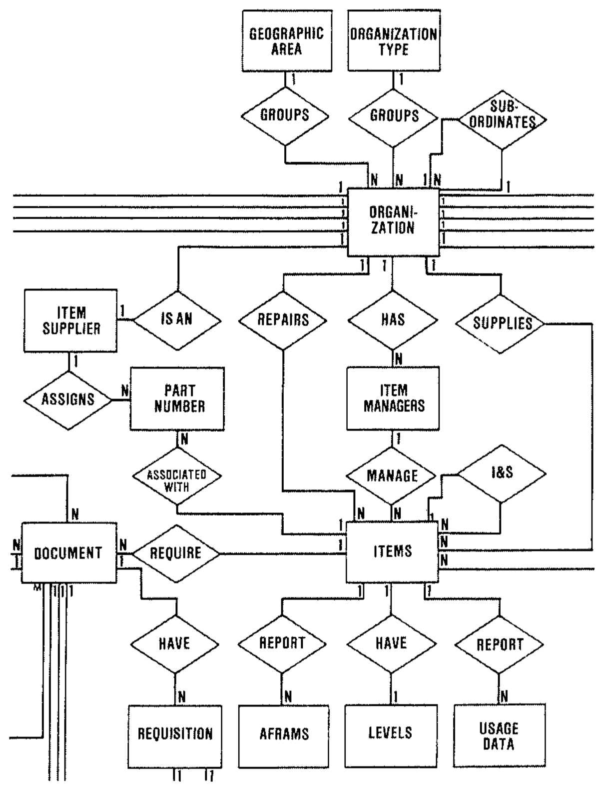

Figure 6: SC&D Conceptual Model.

Entities are represented as boxes on the conceptual model. Task one is to define identifiers (keys) that uniquely identify an occurrence of that entity. For instance the entity ITEMS uses the identifier "item identification number," and the entity REQUISITION uses the identifier "document number." The entities ITEMS and REQUISITION have many other data elements that belong to them.

The specification of identifiers is essential to the proper understanding of how the entities relate to each other. Each data element in the entity must be functionally dependent on the identifier. The results of task two, adding attributes, are defined on the conceptual model with diamonds. Attributes for SC&D were identified from analysis of the MFD, review of actual current system files, and interviews with experts. The attributes, when combined with the entities, form the basis for the conceptual model.

Finally normalization was performed to ensure that each entity represents a discrete person, place, or thing. Normalization supports the description of the inherent data structure of data since it forces the design into a form that represents true entities and relationships rather than any

artificial grouping of data to support a particular application. The resultant lack of bias helps make the database a supportive data repository for all applications. Normalization has been performed on the entities in the conceptual model.

The normalization process reduced each entity to Boyce-Codd Normal Form (BCNF) by eliminating the following discrepancies:

- Repeating groups in an entity (resulting in First Normal Form).
- Dependency of an attribute on only a portion of the identifier (resulting in Second Normal Form).
- Dependency of an attribute on another attribute (resulting in Third Normal Form).
- An attribute that determines another attribute but is not a candidate identifier (resulting in BCNF).

Logical Database Design

A logical database design is then developed for each of the nine SC&D subsystems. The logical database is derived from the portion of the overall conceptual model that is used to support the specific subsystem being developed. The logical model presents the database in a form which can be used by the Database Management System (DBMS).

SC&D uses the Applied Data Research (ADR) DBMS and runs on IBM 3OXX mainframe computers. The conversion from the conceptual model to the logical model is relatively straightforward for SC&D, since we normalize the data in the conceptual design to represent a relational database and the ADR database is relational in nature. Each of the entities is now represented as actual database records with data elements that make up the specific record, and relationships between records are presented with database keys. All this information is captured in the SC&D data dictionary so reports can be processed to support subsystem development.

The logical database is coupled with the preliminary programs in the system specifications and addresses the manner in which the data will be processed by each program in the designed system. Figure 7 presents two programs from

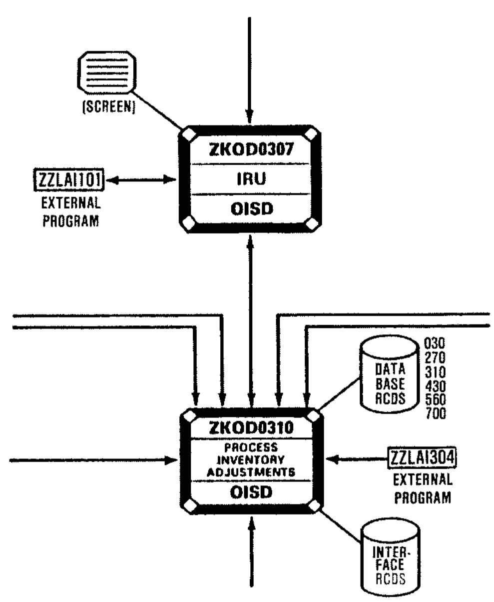

Figure 7: Software Architecture Chart.

more than 350 programs in one SC&D subsystem. SC&D is projected to encompass more than 1,500 programs and more than 2 million lines of code when completed. The chart describes flows between programs, screens generated by programs, interfaces between subsystems, and database records accessed by the program.

Program specifications provide in detail the textual information that supports each program. This analysis between the programs in the system specification and the logical database records allows us to review how the system will work. Questions answered during this review are:

(1) Can all processes be performed by the database structure?

(2) Will the end user be able to access desired data?

(3) Is all data accessible?

(4) Are data access paths quick enough to meet required response times?

(5) Will batch processing be reasonably quick?

Once logical design is completed, the conceptual model is updated to represent knowledge gained and to maintain integrity of the entire design.

Implementing and Tuning the Physical Database

All the information gathered previously to implement a database physically is blended within the hardware/software environment. Physical files are identified from the logical model and are placed on the physical database.

The physical database must be in place before testing of the subsystem can take place. Indices are added or modified as a result of the requirements of the application programs. During module testing, each program's access of the database is analyzed. Integration testing allows groups of programs to be tested against the database.

Finally, system testing provides the capability to run hundreds of thousands of transactions through the database to ensure its integrity. Frequency of backup, database logging, and backout by file and program are all tested at a large test site. Testing is initially performed at the Software Development Facility and later at the first site of implementation. This allows the system production staff to become familiar with the new subsystem and ensures the system meets real world requirements before implementation.

The stable data structure allows development of large portions of software in a staggered manner and minimizes the impact on software. If the physical database changed each time a new subsystem was implemented, massive amounts of changes to software already operating in the field would be required. This would be costly and inefficient, and would greatly curtail the benefits of the new subsystem.

Before the actual implementation at a site, the flat file data that will be loaded in the new database must be "scrubbed" to make sure the correct elements and data are available for the load that will provide initial operational capability (IOC) at each ALC. To install a subsystem at all five ALCs takes six to seven months. The first site is operated about 60 days. This allows the system to be tuned before it is exported to other sites. Performance tuning is a continuous activity during implementation and the maintenance phase.

A database system as large as SC&D requires continuous monitoring not only of the database but also of system software, application software, and communications

interfaces. Updates and software corrections also enter into the equation.

A great deal of research and coordination are required to maintain system operations. A training curve for operations personnel who use the system and have not had prior large-scale database experience must also be taken into consideration when tuning the system.

Figure 8 presents the average batch and on-line transactions that Subsystem 1 processes daily and the associated transaction speeds for each ALC. A key point to realize is that the same software programs are used to process specific transactions for both current batch and new on-line processing. Not only is the database integrated but the software that processes against the database has been designed to be tightly coupled.

Once all the subsystems are implemented, there will be the potential to process 300,000 to 400,000 transactions per day at specific ALCs. Performance tuning is a continual process and, as future subsystems are implemented, optimization will continue.

From start to finish, SC&D has actively involved user personnel from the headquarters and each operational location in the review and evaluation of development documentation, training programs, and implementation activities. The SC&D program management team is located in the same facilities as the development contractor (Computer Sciences Corporation), which has greatly improved communication.

	AVERAGE TRANSACTIONS BATCH	AVERAGE TRANSACTIONS ON LINE
OKLAHOMA CITY ALC	76,000	70,000
SACRAMENTO ALC	76,000	44,000
SAN ANTONIO ALC	111,000	64,000
OGDEN ALC	54,000	53,000
WARNER ROBINS ALC	101,000	76,000
AVERAGE TRANS SPEED	1 SEC	UNDER 1-1.5 SEC

Figure 8: Subsystem 1 Average Daily Performance Statistics.

Meetings can be called at a moment's notice, technical expertise is readily available to the development contractor, and the Government has ready access to the contractor for oversight of the development effort. The teamwork of the user, program management office, and developer has been very effective.

Benefits from the Pilot (CPCI 1) by Using an Integrated Database

As a result of the implementation of the first subsystem, IMs now have the ability to process customer requisitions and exception processing on-line using current asset position data. The IMs can now process mission capability (MICAP) requisitions in seconds versus one to two days. The system managers and IMs now have immediate visibility to the quantity and location of assets with which to make better decisions for distribution. Following are actual examples of benefits that were received during August 1987:

a. 4 Aug, 0700. MICAP Center received a call-in MICAP requisition from a base. The caller was asked to hold the line. Within five seconds after they keyed the requisition number into SC&D, MICAP people were able to tell the caller that stock was on hand, the system had accepted the redistribution order (RDO), and it would ship tomorrow. IN THE OLD SYSTEM, IT WOULD TAKE UP TO 24 HOURS FOR MICAP TO GET STATUS BACK AND UP TO 72 HOURS FOR THE REQUESTING BASE TO GET STATUS. THE NEW SYSTEM GAVE IT TO THE BASE IN FIVE SECONDS.

b. 4 Aug, 0730. MICAP Center received another call-in requisition. Within seven seconds MICAP told the requester that no stock was on hand and the requisition was backordered with an estimated release date of 14 Aug. AGAIN, RESPONSE IN SEVEN SECONDS VERSUS UP TO 72 HOURS IN THE OLD SYSTEM.

c. 5 Aug, sometime in the morning. An IM received a call from a noncommissioned officer (NCO) at a base stating personnel were trying to make a decision on which tail number to deploy on an exercise. To make that decision, they needed an up-to-date status on a particular requisition. Within two seconds after the IM entered the document number, she was able to tell the NCO the "now" status. UNDER THE OLD SYSTEM, IT WOULD HAVE TAKEN UP TO 24 HOURS FOR THE IM TO GET THE STATUS AND CALL THE BASE OR UP TO 72 HOURS FOR THE BASE TO RECEIVE THAT STATUS "THROUGH THE SYSTEM."

d. 4 Aug, sometime in the morning. For some reason, a first level item management supervisor decided a stock number needed a management review. Within six minutes the IM and his supervisor conducted that review by calling up four on-line, real-time screens. UNDER THE OLD SYSTEM IT COULD HAVE TAKEN THE ITEM MANAGER UP TO 72 HOURS JUST TO GET THE DATA TOGETHER TO DO THE REVIEW. SIX MINUTES VERSUS 72 PLUS HOURS TO DO A COMPLETE ITEM REVIEW.

These are only a few of the examples of advantages provided by the implementation of Subsystem 1 at all the ALCs.

Future Benefits from Other Subsystems

The real test will be order and shipping time reductions and their impact on weapon system support once all SC&D subsystems are in place in their integrated database environment. The tools are in place to measure those projected improvements, but the whole SC&D system must be up at all the depots to measure the total impact effectively, since the benefits of the whole are greater than the sum of the parts. However, all indications to date are that the data driven design is stable and that future subsystems will provide the planned benefits.

The lesson learned concerning SC&D is that there are no quick and easy solutions to large-scale development and integration programs. Many groups expound on the concepts of databases, but as Air Force and CSC managers, developers, and implementors have learned, only detailed and extensive planning allows the full advantages to be realized.

SC&D allows AFLC to be more responsive to operational requirements and greatly improves the readiness posture of the Air Force by providing faster, more accurate release and movement decisions using available materiel and transportation to the best advantage of the Air Force. SC&D, developed with an integrated database system, has arrived and there is much more to come.

Air Force Logistics Management Center (AFLMC) FY89 Program

Periodically, AFLMC contributes to this portion of the Journal. Our last contribution appeared in the Summer 1987 edition. Many of the projects in that listing have been completed, and we sincerely hope the Air Force logistics community is more effective because of them.

Cooperative efforts outside the Center have been outstanding. Students and faculty members at Air University and the Air Force Academy provided significant inputs to our projects. Other personnel from MAJCOMs and bases have helped by providing "real world" data, test-bed sites, survey participants, "sounding boards" for new approaches, and key recommendations on better ways to solve logistics problems.

Below are our top projects for FY89 (in-work as of 15 Mar 89). If you are interested in any of these projects, please contact the project officer. If commercial lines are used, dial Area Code 205, 279-plus the last four digits of the AUTOVON number.

FY89 Projects

Verification of M32 Accuracy
Objective: Determine if the M32 Report is providing accurate data.
Maj Loden, Gary, AFLMC/LGS, AV446-4165

Assessment of Economic Order Quantity (EOQ) Hybrid Range Model Performance
Objectives: Determine the actual performance of the hybrid range model. Compute an updated estimate of the cost of implementing the hybrid range model.
Capt Reynolds, Steven B., AFLMC/LGS, AV446-4165

SBSS Reparable Simulation Capability Model
Objective: Develop the capability to simulate reparable stockage policy and repair processes.
Maj Loden, Gary, AFLMC/LGS, AV446-4165

Support General Estimation
Objectives: Create a method to collect and compute the data required to estimate the support general man-hours as an interim approach until the reliability and maintainability information system (REMIS) is operating. Ensure this data is in the proper format to feed the D056 system for use by visibility and management of operating support costs (VAMOSC). Create a method to transfer the data to the D056 system.
Capt Wolford, Bethany R., AFLMC/LGM, AV446-4581

Stock Fund Analysis
Objective: Develop an EOQ simulation model that will assess the impact of materiel acquisition control record (MACR) constraints on the standard base supply system (SBSS). The assessment should evaluate the impact in terms of stockage effectiveness, on-hand inventory, customer due-outs, and the dollar value of requisitions.
Lt Col Matthews, Edward C., AFLMC/LGS, AV446-4165

Test of Airlift Estimator for MAC Cargo Aircraft
Objectives: Using the load estimator/algorithm developed in AFLMC Project LY870104, obtain adequate data and further test the load estimator to better gauge its accuracy. Also develop/test algorithms for cases not addressed in LY870104. The estimator must be capable of being driven by data from the Contingency Operation/Mobility Planning and Execution System (COMPES).
Capt Harris, Michael G., AFLMC/LGT, AV446-4464

Demand Forecasting for Reparables
Objectives: Evaluate the stockage and operational impacts of forecasting the mean and variability of demand for repair cycle assets. Determine accuracy of current method and evaluate alternatives.
Capt Reynolds, Steven B., AFLMC/LGS, AV446-4165

Review of EOQ Stockage Policy Changes
Objectives: Determine the cost of increasing the depth of stock for EOQ items as recommended in AFLMC Reports LS840714 and LS840810. Determine the combined effect on supply performance measures resulting from the implementation of the two studies.
1Lt Cohen, Barbara, AFLMC/LGS, AV446-4165

"Bad Actors" Management Study
Objectives: Develop a specific definition for the term "bad actor" as it relates to line replaceable units/shop replaceable units (LRU/SRU). Collect and analyze data to test the hypothesis that "bad actors" exist as a manageable phenomenon. If the hypothesis of the existence of a manageable "bad actor" phenomenon is supported by analysis, work in close coordination with the Air Force Logistics Command (AFLC) and the major commands to develop standard practices, procedures, and policies for identifying and managing "bad actors."
Capt Getter, William M., AFLMC/LGM, AV446-4581

Core Automated Maintenance System (CAMS) Mobile Terminal
Objectives: Develop technical capability for source data automation (SDA) on Sperry equipment. Determine what data should be passed between SDA equipment and mainframe. Determine changes to CAMS necessary to support SDA. Verify automated maintenance system (AMS) SDA procedures and lessons learned in CAMS environment. Determine the desirability of USAF-wide implementation.
Capt Privette, Michael E., AFLMC/LGM, AV446-4581

Computer-Assisted Instruction (CAI) for Logistics Plans OJT
Objective: Create a CAI system to provide OJT and familiarization training for the five major log plans areas—Mobility, Agreements, Plans, Reception, and War Reserve Materiel (WRM).
MSgt McCray, Charles L., AFLMC/LGX, AV446-3535

Automated Mobility Schedule of Events (AMSOE) Enhancements
Objectives: Rewrite the existing prototype software from PASCAL programming language to "C" programming language. During the rewrite, the AMSOE data base program will be formatted and made compatible with the computer assisted load manifesting (CALM) data base format. Include new options for scheduling and monitoring aids, such as road convoy, enhanced processing parameters, chalk assignment, and others identified by prototype users.
CMSgt Petersdorf, David S., AFLMC/LGX, AV446-3535

Requirements Determination Processes for Consumable Assets in War Readiness Spares Kit/Base-Level Self-Sufficiency (WRSK/BLSS)
Objective: Determine standard method to compute EOQ assets in WRSK/BLSS.
Capt Crimiel, Dennis, AFLMC/LGS, AV446-4165

Application of an Aggregate Model to SBSS Demand Leveling
Objectives: Determine the impact of redesigning the aggregate model to limit the amount of low cost items stocked and increase the amount of some high cost items stocked while staying within the prescribed constraints. Redesign the model to differentiate between critical and noncritical items when computing stock levels. Evaluate all the inventory costs associated with the redesigned model.
Capt Reynolds, Steven B., AFLMC/LGS, AV446-4165

Supply Material Facilities Entry-Level Training
Objective: Create computer based training (CBT) courses to fill the gap between CBT and the 64551 CDC. One course will contain modules which are generic to all supply career fields, i.e., the UNISYS 1100/60 computer, the SBSS inquiries, etc., which we'll use for other projects. Another course will contain modules which relate to each work area of the 645X1 career field.
Lt Col Peterson, Tim O., AFLMC/LGK, AV446-4165

Mobility Bag Inventory System II (MBIS-II)
Objective: Enhance the current MBIS programs to further meet the requirements of the base-level mobility units.
Capt Antalek, Mary L., AFLMC/LGS, AV446-4165

Analysis of Initial Spares Support Lists (ISSL)
Objectives: Investigate current Air Force initial spares support policies and procedures and recommend improvements. Specifically, we will study the current method of establishing the range and depth of ISSL stocks to determine if other stockage schemes can provide more efficient supply support. We also need to study the ISSL update process to determine how actual consumption data can best be used to improve ISSL performance.
Capt Reynolds, Steven B., AFLMC/LGS, AV446-4165

Mobility Miniexercises - Transportation Control Unit
Objective: Develop a guide for miniexercises for the Transportation Control Unit so it can be exercised without committing too many base resources and individual problem areas can be evaluated.
1Lt Patrick, Eric, AFLMC/LGT, AV446-4464

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Air Force Modification Programs—Interaction of Air Force Logistics Command and Air Force Systems Command

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Chief, Enterprise Program and Standardization Policy
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Washington DC 20330-5000

Part I of this article (Winter 1989 issue) discussed the importance of the modification process and the problems of AFSC/AFLC interaction, described the treatment of AFSC/AFLC interaction in the various guidance documents, and provided a review of previous studies and analyses. Part II presents results of informal interviews and gives an analysis/possible solutions of key issues. It concludes with the author's recommendations for resolving those issues.

Part II
Informal Interviews

Informal interviews were conducted with managers from AFSC Special Program Offices (SPOs), AFLC Air Logistics Centers (ALCs), HQ AFSC, HQ AFLC, and HQ USAF. The interviews began with a brief explanation of the study and its purpose, and a few probing questions to get the person started. The goal was to get freely offered opinions of what was right and wrong with modification management, what solutions had been tried and how well they worked, where they saw problems with their counterparts in the other command (and vice versa: the attempt was made to interview direct counterparts) or with their own command, and what they thought might fix the problems. A completely new set of data was not attempted; rather, the purpose was to verify the previous studies' findings and the experience of the author. The choice of interviewees was first based on the weapon system, and then the individual. The weapon systems were chosen on the basis of having achieved Program Management Responsibility Transfer (PMRT) some years earlier, so the ALC would have experience with the system and a significant number of modifications would have gotten underway under the split management process introduced earlier. The individual interviewees were chosen on the basis of having some years' experience with the system either in the SPO or in the ALC's System Program Manager (SPM) office—experience that involved the counterpart command. In order to achieve straightforward answers, anonymity was guaranteed. For that reason, interviewees are only identified by the group to which they belong, and the group's interviews will be discussed together.

AFLC Managers

The perceptions among the AFLC managers varied somewhat in intensity and level of detail provided, but centered on the same subjects identified in the previous studies of this subject. The main topics were problems with communication (sometimes with receptiveness to inputs), definition of the relationship that does or should exist between the commands, the adequacy of relevant regulations and direction (PMDs), and the idea that success was personality dependent, rather than due to a good system or process. When asked about communication, two respondents perceived that the AFSC SPOs seemed unwilling to accept inputs or were somewhat arrogant. The perceived attitude was one of "we know what's best for you, AFLC." (5) In some cases, they reported AFSC did maintain communication, but then pursued its own course. Where communication seemed very good, there also was a Memorandum of Agreement (MOA) in existence which defined the relationship between the commands and established reporting and cross-coordination requirements. This was the case on the F-111 Digital Flight Control System (DFCS) program. Although the MOA was never invoked, it existed and everyone knew it—and its procedures were followed. In another situation the reverse was true. No MOA existed, and the SPO seemed to ignore the authority of the SPM which existed tenuously by regulation even if not defined in an MOA (paraphrasing the interviewee). (5)

The adequacy of regulations caused problems for the AFLC interviewees. As mentioned earlier, AFSC managers recognized the 800-series regulations as applicable. The 57-series regulations, bible to AFLC, were little known in AFSC. The interviewees reported problems with formats—modification program management plans (MPMP), for example, were subject to one format in AFR 57-4, *Modification Approval and Management,* and another (as program management plans (PMP)) in AFR 800-2, *Acquisition Program Management*. Another problem reported was that the 800-series regulations clearly stated that the program manager was in charge, but AFR 57-4 stated, through the configuration control sections and the total weapon system management approach, that the SPM had responsibility for integrating modifications. It is tenuous at best. Closely related to the problem of adequate regulations was the problem of consistent and compatible Program Management Directives (PMD). One SPM said PMDs ranged from vague and very basic, forcing the SPM and program manager to make up their own rules, to extremely detailed, leaving the managers no flexibility at all. This individual concluded that those who write PMDs have no training or guidance on how to write them. Other problems with PMDs were the absence of any reference to the SPM as the single point manager and the need for an overall weapon system PMD that established basic ground rules and authorities for all modifications. Currently, for any given weapon system, there may be dozens of PMDs in force, each for a different modification, with no apparent attempt to make them consistent or to relate one modification to any others. Another interviewee disagreed, saying that on his program the PMDs seemed to be improving and becoming more integrated. He also commented, however, that the contractor was integrator

for modifications on his program and that the Air Force really had no formal mechanism for keeping up with all the modifications.

Some interviewees mentioned that success in command interaction was dependent on the personalities and degree of commitment of the modification program managers and their counterparts. If those managers were committed to supportability, to making the modification work on the weapon system, not just while it is his or her watch, the interaction and coordination worked very well. One example cited again was the F-111 DFCS, where both the AFSC and the AFLC managers were very committed to making the interface work. However, if there was any sense of condescension from AFSC to AFLC, the interaction quality declined. Another interviewee cited a case where the SPO treated AFLC as an afterthought, approving documents in-house and only then showing them to AFLC, too late for any comments to be made and incorporated. (5) This is unacceptable. The system needs to incorporate the ingredients of success, so success is assured by following the guidance and direction, rather than by good intentions alone. One interviewee observed that the relationship between AFLC and AFSC should be:

> . . . like a doctor-patient relationship or lawyer-client relationship. AFSC is the expert, hired by AFLC to provide advice and counsel. But, AFLC has the right to choose not to follow the advice and accept the responsibilities for the consequences. (5)

The exception to this approach, brought out by the same person, is when AFSC is developing a standard box to be installed on a variety of platforms. Then AFSC needs to define the relationship with each SPM involved, and the SPMs should back off and recognize the special problems of that situation.

Some miscellaneous comments were that modification PMRT had to be very carefully timed to ensure the SPO would not be forced out of business before the residual tasks were complete. In at least one case the AFSC SPO did not understand the need for supportability thinking up front. That was only mentioned once, however, so it was thought to be an isolated case.

AFSC Managers

The AFSC managers interviewed mentioned some of the same problems, but their responses indicated more variance in the seriousness of the problem. These managers also identified problems with communication, definition of the relationship between the commands, and the dependence of success on the personalities involved. However, they did not see any inadequacy in regulations or PMDs. They agreed it was important for PMDs to be consistent, but felt that they generally were pretty good. There seemed to be less awareness of the inadequacies in the regulations, although at least one manager brought it up. Communication seemed to be best where MOAs existed, as was the case in the F-111 DFCS, the F-111 Avionics Modernization Program (AMP), the F-15 program, and the Minuteman Program. In the latter case, the PMP of the Minuteman Long Range Plan stated that it would serve as an MOA among AFSC, AFLC, and SAC. It also formally set up an organization which involved executive committees, steering committees, and several working groups that were chaired by a representative from one of the commands. In the case of the F-15, the PMRT agreement served to define the relationship of the involved commands. (9) All the interviewees who were working under agreements said there was still conflict at times, but with the MOA (or PMP or PMRT agreement) in place, and the knowledge that everyone was working for the good of the weapon system, the conflicts seemed to work out without recourse to higher levels of authority. (6) This is similar to the comments made by the AFLC interviewees regarding the effect of MOAs on the working relationship. It is difficult in this set of interviews to separate the comments about the relationship between the commands from the communication between the commands. Good communication depended, in most interviewees' minds, on how well the intercommand relationship was thought out. Problems seemed to occur in communication only when contrary assumptions about procedures or authority (who is in charge) were possible. If those contrary assumptions could be made, then the problems were perceived as large. (6)

The AFSC interviewees recognized that success was dependent to a large degree on personality just as the AFLC interviewees did, but not to the same degree. Where the structure (due to an MOA) was clearly defined, they seemed to feel success was less personality dependent, although still true to some extent. They perceived that outstanding success would always be dependent on the individual's commitment to making the relationship between the commands work, regardless of the structure, but that having a well-defined structure reduced that dependence. One interviewee felt the personnel selection criteria used were very important. He had been selected as manager of a long-range modification program specifically because of his experience and perspectives as an ALC manager. This suggested that some crossflow of AFSC and AFLC could have value for training modification managers. (6)

The AFSC interviewees did not have as much concern about the inadequacy of regulations and PMDs. There seemed to be a feeling that modifications were not all that different from regular acquisitions, at least in the development process. One interviewee did note the conflict in formats for PMPs (or MPMPs). Another specifically responded that PMDs seemed to be consistent in quality and appeared to reflect communication between the action officers in USAF/RD (now SAF/AQ) and USAF/LE. (6)

The individuals also made other miscellaneous AFSC comments. One interviewee stated that while the relationship with the SPM organization was excellent, the relationship with the item manager's (IM) organization had significant problems. This was attributed to the fact that involvement with the IM's organization had taken place only at the lowest levels during the planning process. No mid-level managers were involved or identifiable. When problems arose, the lower levels buried them, and no pressure seemed to work to solve the problems until AFSC elevated the problem to the three-star level—at which point it was beyond any simple recovery. This manager recommended that any agreements (like MOAs) include the IM organization, but at a higher level than the IM. Another interviewee reported that one key to success in the F-15 program had been assigning AFLC individuals, whose performance was assessed by the SPM, to the SPO. (6)

Headquarters Managers

Only one interview at the headquarters level provided information relevant to the question of command interaction on modification management. This interviewee managed modification funding from the Air Staff and had visibility into all significant ongoing modifications. In his view, the problems in modification management were lack of communication, lack of hard work, and a "not my job

syndrome." He believed there was nothing wrong with the process and that hard work would do the job, and backed that up by relating a case where he directed an ALC to use the basic, existing system to get a modification funded, rather than elevating the problem for special consideration. He said the modification was funded in six months, using the system, with lots of hard work by the managers involved. The importance of communication in getting a modification developed and implemented, he felt, was well illustrated by the Global Positioning System (GPS). The GPS user equipment will be installed on every operational aircraft in the Air Force, so it involves every ALC, three AFSC product divisions, and all users. Considering the need to fit on all aircraft, the desire for standard equipment to the maximum extent possible, and all the organizations involved, success is only possible with excellent communication and clear understanding of the responsibilities and roles of each organization. The GPS SPO has an MOA which defines the responsibilities and roles of the organizations. Both this interviewee and the SPM of one of the affected aircraft were impressed with the communication maintained with the GPS SPO. (1) (5) As with the AFSC and AFLC interviews, there seemed to be a connection between the existence of an MOA and the quality of communication between the commands. The "not my job syndrome" he believed can occur anywhere, but it is particularly damaging between the two commands where communication and cooperation on modification programs are so important. When asked about PMDs, the interviewee stated that there is a mystique about PMDs that should not be there. PMDs are just documents written by action officers that can and should be changed when necessary—they are "not chiseled in stone." (1) He agreed that lack of TDY funding is a problem for the AFLC managers, but said he could not seem to solve it at his level. He had included TDY funding in budgets previously, only to see it cut at higher levels or used for other things at AFLC level or below. (1)

While this interviewee's views were not representative of the entire headquarters, they did represent the experience of an expert in modification management whose current position exposes him to all the modification management problems. For this reason he was interviewed and his thoughts included.

Analysis: Key Issues and Possible Solutions

It is now possible to distill some key issues or problems that exist with the interaction between AFSC and AFLC. The preponderance of evidence says that AFSC/AFLC interaction is indeed critical. The nature of the relationship between AFSC and AFLC is not so easily pinned down. From all the examples in the studies, the lessons learned, and related by the interviewees, as well as the other examples known to the author, the relationship between the commands varies according to the needs of the individual weapon system and even according to the needs of the individual modification. Only the fact of split management, and therefore the criticality of the interaction between the commands, is constant from example to example. The issues, then, center on how to optimize this interaction to ensure that management of modifications is as successful as possible.

Definition of Responsibilities and Authority

Analysis. The issue of definition of responsibilities and authority encompasses the problems of split management and "who's in charge." It also ties to the next issue regarding the adequacy of the guidance. The roles and responsibilities of AFSC and AFLC are generically defined in the various regulations reviewed earlier and usually further defined in the PMDs. Over the years of studies, many have suggested establishing a single manager for modifications (assumed to mean for each weapon system, versus one for all modifications everywhere). The problem seems to lie with three missing things: (1) a specific statement of who has authority over what, (2) the understanding of each other's responsibilities, and (3) agreement on both. In each of the cited examples (GPS, F-111 DFCS, F-111 AMP, F-15, Minuteman) where an agreement had been formalized, the organizations involved had worked out for themselves who had authority and who had responsibility for what. The result, at least at the manager's level, seemed to be a clear understanding of the unique roles and responsibilities of each other's organization.

Possible Solutions.Three different approaches could reduce or solve the problem. The radical solution would be to combine AFSC and AFLC, so the single authority of the commander of the joined commands could rule. Aside from the unlikeliness of this proposal ever being accepted, it would not necessarily improve interaction between the two segments. For example, the current organizational structure has all the ALCs under AFLC, but that does not keep the ALCs from having problems with the relationships among themselves. Another less radical solution would be to rewrite the applicable regulations, strengthening the division of roles, responsibility, and authority. The rewritten regulations would then eliminate the uncertainty and ambiguity that exist today. This solution would be far more acceptable than the first one. But, it seems that the successful managers work it out for themselves under current regulations. Rather than overriding a system that can (and has) worked by rewriting regulations to define roles, responsibility, and authority, perhaps the more reasonable approach would be to add a requirement to the regulations which effects an agreement of some kind between the AFSC SPO and the applicable AFLC ALCs, both SPMs and IMs. This way a technique that has been shown to work is mandated, but the mechanics, which are unique to each modification, can be worked out to suit the situation. Furthermore, it tends to drive the solution downward to the managers who know those unique features, rather than elevating it to the headquarters level. This would make the solution more acceptable to the managers (AFSC and AFLC). It would also eliminate the potential need for waivers to accommodate unique situations that simply could not fit into a mandated solution.

Communication

Analysis. While it is clear from the studies and interviews that close communication between the commands is vitally necessary, it is not easy to mandate it. However, it was also evident from the studies and interviews, as well as the author's experience, that good communication seemed to accompany the existence of an MOA. What is not clear is whether a cause and effect relationship exists between MOAs and good communication—either way. It is reasonable to assume, however, that the interplay necessary to create an MOA could only improve the communication environment, since the participants would be clarifying roles, responsibilities, and authority. This would serve to eliminate erroneous assumptions and bring into the open all the tasks to be accomplished by the two commands. Therefore, the

alternative of mandating an MOA to be accomplished by the participating managers seems to be applicable to communication as well. Another technique used by some programs is to create a long-range plan or master plan for the weapon system. This too seemed to improve communication, as long as anyone preparing modifications for incorporation into the system was included in preparation of the master plan. There tended to be frequent updates to the plans, due not only to problems in development, but also to budget problems and requirements changes. The update process improved communication even more, or at least drove recognition of ripple effects on other modifications or on the weapon system, which after all is the goal of better communication. This also suggests the *process* is the important part, more so than the paper that results. Updates shortly after a change of key personnel may be needed. Finally, there is the technique of establishing executive committees, or steering groups, with subcommittees and working groups to carry out the taskings of the higher level committees. With members at each level from all the participating organizations in AFLC, AFSC, and the using commands, and sometimes from the headquarters, communication is enhanced by the periodic meetings and by the subsequent follow-up actions. A final proposal would be simply to emphasize the need for good and regular communication through training courses, commanders' tips, inspector general tips for program managers, and handbooks or pamphlets that address management of modifications. This has actually already been done to some extent—the AFSC Chief of Staff sent out a brochure in 1986 with some pitfalls for the program manager to avoid. One of them focused on the need for communication and involvement of the participating commands in any program, whether modification or pure acquisition. (8:23)

Possible Solutions. Unlike the alternative solutions for the first issue, the alternatives for improving communication are not mutually exclusive. There may be certain minimum actions. For example, the MOA approach seems to work under any circumstance. It is flexible enough to be used even on fairly small programs, or on very big, complex programs with many organizations involved. Making it mandatory would ensure a certain minimum level of communication. Emphasizing the need for good communication will always be necessary. It is basic to training new managers, who are always coming along, and it can always help to review the subject with experienced managers. These two approaches fit well together and seem to be minimum solutions to the problem. If the problem is very complex, with multiple modifications coming at many different times from a variety of organizations, then the master plan or long-range plan would be suitable. If there are very few modifications planned, then a comprehensive plan may not be necessary. The determination whether to use one could be left to the SPM or directed in the PMD. Formats for plans again could be left to the SPM or included in a regulation such as AFR 800-2. Establishing committees might be considered the next step up in complexity and size, although it certainly could be done concurrently with master plans and MOAs. All four actions could apply to a single program. although the F-15 and Minuteman example programs repl[illegible]d MOAs with the more extensive PMRT plan and PMP respectively.

Adequacy of Guidance Documents

Analysis. The problem of adequate guidance documents is divided into two parts: regulatory guidance and program unique guidance (PMDs). The regulatory guidance can be further categorized into regulations, which are binding, and pamphlets, which are advisory. There are some inadequacies in the regulations. Primarily, the problem is that most related regulations almost completely ignore modifications. The big exceptions are AFR 57-4, which comprehensively describes the types of modifications and the approval process, and AFR 57-7, which describes in detail the funding documents for modification. (2)(3) AFR 800-2, as described earlier, barely mentions major modifications in its statement of scope and never again addresses any of the unique aspects of modification programs. (4:1) The problem, therefore, is the unique aspects, requirements, and problems of modification management are not addressed in the regulations. Another problem in the regulations is the absence of authority for the SPM. AFR 57-4 states that the SPM has the responsibility for integrating modifications after PMRT (2:5), but nowhere does the regulation assign the authority for integrating decisions to the SPM. The pamphlets yield more, but they only provide advice. AFSCP 57-2, *Modification Management,* does provide information and advice on modification management for the AFSC manager (not to the SPM), but not any specific techniques for implementation. (7) It is also seriously out of date, having been last issued in 1982, which is before AFSC began managing many Class IV modifications. AFLCP/AFSCP 800-34, *Acquisition Logistics Management,* which is at least joint, provides advice on Class V modifications but totally ignores Class IV modifications, and does not provide any suggested techniques. It is a current document with an issue date in 1987. There may also be some problems that result from failure to follow the existing regulations. While this seems to be true, it is far more pervasive than these few regulations and so deserves study as a separate subject.

Program Management Directive. The second guidance document that is frequently inadequate is the PMD. PMDs are written by the action officers at USAF/LE and SAF/AQ to provide specific direction, funding, and required schedules to acquisition and modification programs. A separate PMD is usually written for each modification program. If the modification is a Class V modification program originated by AFSC with development work involved, then SAF/AQ normally writes the PMD. If it is a Class IV modification, or a Class V modification in production, USAF/LE normally writes the PMD. Exceptions exist to both of these. The problem is that there appears to be little or no coordination between the action officers from PMD to PMD. No overall PMD is issued to override all the modification PMDs and provide the SPM with baseline direction and priority of modifications. Nor is there any basis for requiring the various modification program managers to accede to the SPM. (5) Nothing ties all those modifications together, and so the various modification program managers point to their own PMD as justification for actions and decisions. Another problem with PMDs is they either give too little detailed direction, which is therefore too vague for the SPM, or provide far too much detail, which takes away the SPM's flexibility.

Possible Solutions. For the regulations, fairly minor changes to the regulations could extend applicability and provide a basis for some of the actions suggested previously. For example, the requirement to develop an MOA between the AFLC SPM and the AFSC SPO could be included in both AFR 57-4 and AFR 800-2. The alternative would be to put the requirement in AFR 57-4 only and have AFR 800-2 strongly

reference AFR 57-4 for the management of modifications. Similarly, addition of authority assignment to the SPM could be a one- or two-word addition to page 5 of AFR 57-4. As it happens, the Goldwater-Nichols Law has forced many of these regulations into revision. Incorporating minor changes to make them compatible with each other should not be difficult. The updates to the pamphlets AFSCP 57-2 and AFLCP/AFSCP 800-34 should be considerably more comprehensive. For example, inclusion of Class IV modifications as work that may be done by AFSC requires a new addition to both. Also, AFSCP 57-2 would probably be improved if it were made joint with AFLC. Then it could draw on the expertise of AFLC to ensure its correctness and provide advice to the SPMs on modification management. With some additions, these new joint pamphlets could provide SPOs and SPMs advice on working together and assuring good communication.

Two suggestions could alleviate the problems with PMDs. One would be to begin issuing an overall PMD for each weapon system that tracks to the philosophy of the master plan. This "master" PMD would override any other PMDs for modifications for that weapon system. A standard level of detail should be maintained to allow significant flexibility, but the authority of the SPM should be clearly established with regard to changes to the weapon system. This would immediately remove the unsolvable conflicts, but hopefully it would also influence the various action officers to bring the PMDs for which they are responsible into line with the overall PMD and to become involved in the issuance of each other's PMDs. The second suggestion is to establish some standard or operating instruction for the issuance of PMDs. If properly written, it could strike a good balance for the level of detail required in a PMD. (Shortly after this report was submitted to ACSC, HQ OI 800-2 was issued to provide guidance for writing PMDs. It, combined with assiduous application by the reviewing office, is rapidly improving the quality of PMDs.)

Personality-Dependent Success

Analysis. It was frequently mentioned in the studies and interviews that successful interaction between the commands depended heavily on the personalities of the managers assigned to AFSC and AFLC. If the AFSC manager was strongly committed to making the interaction between the commands work, it usually did work, assuming the AFLC manager was similarly involved. If the AFSC manager had a case of the "not my job syndrome," there was generally little interaction and significant problems with modification integration resulted. The AFLC managers have two problems. They must not only be committed to making the modification program work, but must have sufficient TDY funds available to travel to the necessary meetings. The problem of sufficient TDY funding was raised by several of the studies reviewed as well as by the managers interviewed.

Possible Solutions. In order to get managers committed to a way of doing business, they must first be informed a method exists and secondly be convinced the method is beneficial to their program's success. This suggests that training managers specifically on modification management would be advisable. This could be incorporated into the existing program management training, AFIT courses SYS 100, 200, and 400. It could be a one- or two-day course by itself, or be made into an Extension Course Institute (ECI) program, to be taken by correspondence. This approach is direct, but it would require justification to develop another course, time to develop the course chosen, and time to cycle the managers through the training. Unless the training was mandatory (unlikely, since it is not unique to any one career field), there might not be enough interest to get the program managers to attend the course. Another approach, given the update and upgrade of the pamphlets suggested earlier, would be to call out those pamphlets in the PMD Authorization and Deviation paragraph for the manager to use for advice in modification management. The pamphlets could at least be made freely available (not restricted in distribution like regulations) at the AFSC product divisions and at the ALCs, and incorporated into job specific training. Using the pamphlets, once upgraded, would be much simpler and less expensive (intuitively) than developing and administering a training course. These suggestions cannot totally remove the personality dependence of success in modification management and interaction, but they can reduce the disparity between the committed, knowledgeable manager and the less committed, but at least knowledgeable, manager.

Recommendations

After analyzing all the results of this study, I recommend the following solutions for resolving the four issues discussed:

(1) *Need for definition of responsibilities and authority.* Recommend add a requirement to either the current applicable regulations or to every modification program PMD that a written, signed agreement be prepared between the AFSC and AFLC organizations. That agreement would define the role, responsibility, and authority of each participant, and would require updating/re-signing whenever key program personnel turnover occurred.

(2) *Communication between commands.*

a. Require all modification programs to enact an agreement (same as the first recommendation) through a change to regulations or PMD direction.

b. Emphasize the need for good communication in management training courses, articles in command publications, inspection team tips, and handbooks or pamphlets on modification management.

c. If the SPM or AFLC Headquarters determines it necessary due to complexity, develop a long-range plan or master plan for the weapon system, encompassing all modifications and signed by all organizations involved in managing modifications for that weapon system.

d. Where determined necessary by the SPM or Headquarters AFLC, due to complexity of the planned modifications, establish a system of committees, such as a steering committee, an executive committee, and working groups that involve the relevant organizations.

(3) *Adequacy of guidance documents.*

a. Add the following to the applicable regulations: the requirement for MOAs, the provision for long-range or master plans along with a format, the provision for a system of committees, the authority of the SPM following PMRT, and the missing information on current management of modifications. Modify the regulations to make formats consistent. The choice of which regulations to change belongs to the Office of Primary Responsibility (OPR) for the regulations, but the choices should be coordinated among the OPRs for the related regulations.

b. Revise and expand the existing pamphlets on modification management to recognize current trends, include regulation changes (including the recommended changes already mentioned), and include suggested techniques for

improving interaction between the commands.

c. Establish a policy to issue overall PMDs for each weapon system. The overall PMDs should establish the modification philosophy and authority chain for that weapon system.

(4) *Personality-dependent success.*

a. Implement the recommendations in (3) to provide the basic structure for successful interaction.

b. Make the revised pamphlets freely available and part of job training for managers in AFIT, in SPOs, and in SPM and IM offices.

The recommendations provided make small improvements on a basically sound system. Many SPMs and program managers have already discovered and successfully used many of the techniques suggested. The purpose of the recommendations is to provide an institutional framework within which all managers can more easily be successful.

Conclusion

The final task, then, is to answer the question posed in Part I of this paper: Can guidance be provided to facilitate the interaction of AFSC SPO personnel with AFLC SPMs during the AFSC development and production of Class IV and Class V modifications to weapon systems under AFLC control? The recommendations provided answer the question "yes" and also provide the "how."

Success in modification management is becoming more important than ever as the Air Force relies on it more. One of the sponsors of this paper, who was then the Assistant Deputy Chief of Staff for Product Assurance and Acquisition Logistics, estimated that "70-80 percent of the aircraft on the ramp today will be active for another 20 years." (6) That means even more modifications will be programmed to keep those aircraft current. We need to succeed in modification management to maintain and improve our capability to defend the nation. With the few changes recommended by this article, the potential for success improves.

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4. US Department of the Air Force. *Acquisition Program Management.* Air Force Regulation 800-2, Washington DC: Government Printing Office, 1985.
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▶ *Continued from page 19*

Health of Supply Measurements
Objective: Based on the influence relationships between various inputs to the supply system, develop a knowledge system which provides a macro-level measure for the health of the supply system.
Lt Col Peterson, Tim O., AFLMC/LGK, AV446-4165

Stand Alone LOGMOD-B
Objective: Create a system to allow units to process most LOGMOD-B transactions using a microcomputer.
CMSgt Petersdorf, David S., AFLMC/LGX, AV446-3535

Definition of the Employment Role of Logistics Planners
Objective: Define the role of the logistics planner during employment operations.
Capt Fryer, Larry M., AFLMC/LGX, AV446-3535

Nonconforming Screw Thread Products
Objectives: Identify methods to measure what effect nonconforming hardware has on operational units (dropped objects, man-hours consumption, loss and missing hardware, etc.). Determine if these areas of selected measurement quantitatively improve if a unit exclusively uses MIL-STD conforming hardware.
Capt Fandre, Donald C., AFLMC/LGM, AV446-4581

F-16 Fault Diagnostic Study
Objectives: After the Coronet Warrior II (CWII) exercise, conduct an analysis of CWII data to identify potential improvements for F-16 built-in test (BIT) performance for engineering review and identify potential improvements for the F-16 fault reporting/fault isolation (FR/FI) process.
Capt Silva, James T., AFLMC/LGM, AV446-4581

Conventional Munitions Employment Planning Guide
Objective: Develop a conventional munitions employment planning guide for unit-level munitions managers.
CMSgt Richardson, Allen C., Jr., AFLMC/LGM, AV446-4581

Analysis of the Repair Cycle Data System (Dirty DIFM)
Objectives: Analyze the repair cycle data system and the associated documentation to determine the extent to which data collection/ documentation errors exist. Determine the impact of any such errors on base pipeline computations. Recommend system improvements.
Lt Col Matthews, Edward C., AFLMC/LGS, AV446-4165

Freight Documentation Automation (FDA) Surface Freight Transportation Control and Movement Document (TCMD)
Objective: Reduce manual workload by automating data entry, storage, and output in the overseas base level surface freight transportation functions. To reduce data entry errors, we will provide a means to transfer common data for the packing and crating function to the surface freight function. This project will add TCMD capability to the CONUS program produced under project LT861046. The TCMD is the primary document used for cargo movements at overseas locations.
Capt Mohr, David W. AFLMC/LGT, AV446-4464

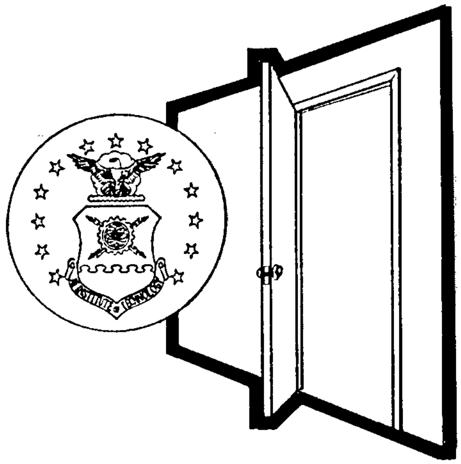
Inventory Analysis Program II (IAP-II)
Objective: Enhance the IAP and command-level (CIAP) programs to meet the requirements of base and command-level managers. The necessary enhancements will be identified in the requirements document.
Capt Antalek, Mary L., AFLMC/LGS, AV446-4165

AFLC Inspector General Criteria Development
Objective: Develop the necessary criteria which set the mission function standards. Criteria shall provide inspection guidance broad enough to facilitate inspector judgement.
Capt Renkas, John, AFLMC/LGM, AV446-4581

Recommended Reading:

Peppers, Jerome G., Jr. *A History of United States Military Logistics, 1935-1985.* Logistics Education Foundation Publishing, Huntsville AL, 1988. This book relates the problems faced by military logisticians and the solutions derived in their efforts to succeed in supporting the combat forces so they might achieve victory. It presents important lessons to be learned and remembered as logisticians plan for their readiness for national defense.

AFIT



The Doorway to Logistics Success

AFIT Checkpoints

The Doorway to Logistics Success

The graduate education programs at the School of Systems and Logistics (LS), Air Force Institute of Technology (AFIT), continue to be well attended by USAF officers and well supported by the MAJCOMs and the Air Staff. There will be approximately 175 graduates this coming fall, of which 90 will receive degrees in either logistics management or engineering management. Core logistics disciplines are primarily taught by experienced loggies and civil engineers who are afforded the opportunity to attend a Ph.D. program at a civilian university prior to joining the faculty. Officers interested in finding out more about AFIT graduate educational programs should consult AFR 50-5, *USAF Formal Schools*, for the master's programs or Dr. Craig Brandt, AUTOVON 785-4149, for information regarding faculty duty.

In the short course or Professional Continuing Education (PCE) area, AFIT enrolled 6,500 students at its Wright-Patterson AFB schoolhouse. Other modes, such as on-site offerings in which AFIT funds its instructors to go TDY to an operational site to give a course, brought the total number of students receiving AFIT education to over 17,000.

Besides class work, AFIT instructors engage in consulting to Air Force organizations. For example, in quality management techniques, AFIT is clearly leading the Defense Department in making total quality management (TQM) techniques work for us. For more than a year, the School of Systems and Logistics has had teams of faculty members working closely with the Air Force Logistics Command (AFLC) and each air logistics center to assist AFLC in implementing TQM techniques and attitudes throughout the command. The AFIT faculty members have presented short workshops and training sessions that taught more than 5,000 AFLC employees about the quality improvement techniques advocated by Deming, Taguchi, Juran, and Crosby. The methods of process analysis and continuous process improvement are being applied with great success to a range of activities. In addition to the workshops, some of those faculty members are advising the AFLC Quality Council on appropriate strategies that will help implement TQM throughout the command.

A third area of significant AFIT activity is in research. Three theses which might be of interest to loggies are summarized below; each may be acquired through DTIC.

TITLE: *Depot Maintenance Parts Demand Distribution and Evaluation of Alternative Stockage Policies*

AUTHOR: Steven H. McBride

Depot maintenance makes many efforts to plan parts requirements and assure adequate stocks are available to meet demands. Nevertheless, many parts with recurring usage never seem to be adequately stocked to support actual requests. Building upon research by the Air Force Logistics Management Center (AFLMC), which studied variability of demand at the base level, this research investigated variability of demand for depot level maintenance. The purpose of this study was (1) to determine assumptions made by the maintenance inventory center (MIC) and D033 stockage models in regards to demand, (2) to analyze actual depot maintenance parts demands and assess if these assumptions were valid, and (3) to evaluate (simulate) alternative MIC stockage policies.

The research suggested current MIC stockage policy was not capable of providing overall 95% line item fill rates as presented by certain data automation reports. The D033 (O&ST) safety level equation was also examined, and research indicated it did not adequately accommodate observed variance in demand. Simulations showed the current 30/15 day (stock level/reorder point) policy is good for many expendable items. However, a simulated hybrid lot size and safety level approach can maintain similar line item fill rates and simultaneously reduce stock levels for some items.

TITLE: *A Computer Based Data Management System for Air Force War Reserve Materiel (WRM) Vehicle Management*

AUTHOR: 1st Lt Robert S. Thomas

The purpose of this research was to determine the feasibility of developing a microcomputer based system for use by transportation personnel to manage the war readiness materiel (WRM) fleet. This research determined user requirements, developed a prototype system, and validated the prototype system through pre-field testing in coordination with AFLMC transportation personnel and HQ PACAF/LGT. The system is designed to accept both manual and automated input from the Vehicle Integrated Management System (VIMS) and the AFLMC Vehicle Automated Management System (VAMS).

The WRM Vehicle Management System provides capability for vehicle dispersal/distribution management, scheduled actions management, release case management, and a variety of reports. The end product is a compiled computer program on a single 5 1/4-inch "floppy disk" that can be freely distributed and will operate on Z-248 microcomputers.

TITLE: *Fraternization in the United States Air Force: Development of a Policy Booklet*

AUTHOR: Capt Richard T. Devereaux

This research proved that a definable Air Force policy on fraternization exists, but that the sources of policy guidance are not complete by themselves. The study indicated there is some confusion and a lack of knowledge about the fraternization policy throughout the Air Force.

To solve the problem, the author produced a stand-alone *Fraternization Reference Booklet* that integrates regulations, policy letters, court cases, and other official policy sources. This booklet clarifies the fraternization issues, policy specifics, and "gray" areas where interpretation is left to individual commanders.

Bashing the Technology Insertion Barriers

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Introduction

''We have met the barriers, and they are us....''

This fractured paraphrase of the Alligator's infamous line from the comic strip ''POGO'' best illustrates the use, or more correctly, the lack of use of new technology on the Department of Defense's (DOD) weapon systems.

Most technologists lament the long and difficult time for getting a technology operationally fielded. This paper focuses on barriers the Air Force faces in fielding technologies. Although the discussion of barriers applies to almost all technologies, I have limited my paper to those which address or enhance the Air Force's R&M 2000 goals.

Barriers are often similar whether we are trying to inject new technology into a new weapon system or into existing systems. However, barriers may be different when we are looking at the first-time use or the follow-on use of technology. I will focus on the follow-on use of technology for both new and existing weapon systems. We define this as technology transfusion. In other words, I have eliminated the ''t'ain't never been used before'' barrier from my discussion.

Technology Transfusion

Technology transfusion is the follow-on use of new technology which has been successfully introduced into operational use or has been successfully demonstrated in an operational prototype. All too often a once introduced technology becomes an orphan. Once used, the Air Force does not continue to market the technology to other systems. Opportunities to use the technology on new systems are infrequent because new weapon systems are not introduced into operational service very often. Hence, the opportunity for continued or follow-on exposure to new systems is severely limited. I will not even begin to address the issue of the lead time between technology consideration (weapon system conceptual phase) and its field use (production and deployment phase).

Given that few new weapon systems come into the Air Force, what are our other targets of opportunity? Within the Air Force Systems Command (AFSC), there are Pre-Planned Product Improvement (P^3I) programs or production block changes and upgrades. These are often accomplished through Engineering Change Proposals and Value Engineering projects. In the Air Force Logistics Command (AFLC), there are Class IV and V Modifications, Preferred Spares, and the Multi-Stage Improvement Program. These programs are designed to introduce upgrades to deployed weapon systems or their subsystems.

The straightforward purposes of these programs belie the lack of ease under which each is administered. As soon as we start down the road to technology transfusion, we will meet more barriers than we would envision in a bad dream.

Barriers

To introduce the follow-on use of any worthy technology, all one has to do is ''simply cut through the bureaucratic red tape.'' Simple in statement—difficult in action. And it is impossible to the fatalist. The quixotic challenge is to knock down the barriers the bureaucracy constructs and fosters—not go around, but actually knock down and destroy when necessary. Hopefully this paper will help identify barriers and provide insights so we will be better prepared to do battle.

Admittedly, the barriers exist to protect against some past abuse, to assure the job gets done correctly, to ensure safety and standardization, and to prevent other problems created by untested technology.

There is no question that some barriers, or those things created as gateways, are valid and necessary for consistency and control of an otherwise rampant anarchy. After reviewing numerous technology insertion efforts, I can see three major types of barriers: technical, regulatory, and people. Technical barriers encompass technology application concerns and the technology's ability to actually do the job in the field. Regulatory barriers concern control, procurement, and administrative issues. People barriers center on the attitudes and perceptions of people. The ''We have met the barriers, and they are us'' attitude flourishes in the people arena.

We may find some of the same barrier titles repeated in each arena. These barriers may have the same name, but they have different characteristics. An example is the barrier of ''Not Enough Tech Data.'' In the technical arena, this barrier is characterized by actually not having enough of the field level data which would verify the usefulness of the technology in the field. The people arena version of this barrier has the characteristic of never ever having enough data. Individuals who are throwing up this barrier do not really want to see our technology succeed. They could be adverse to change, to risk, or even to additional workload. Hence, the strategies for overcoming each of these barriers may depend upon the underlying nature of the barrier.

Before delving into the barriers themselves, let me define some terms. I will refer to the person or organization who will use the technology as the ''user.'' The term is broad in context

and may refer to the blue suiter in the field, the depot floor technician, or even the manager in the air logistics center. "Field" is also a generic term which applies to the air base or the depot.

Keep in perspective that researchers, developers, appliers, and users probably have "cultural" differences which stem from their education, environment, goals, and objectives.

Technical Barriers

These barriers encompass the technical issues. They attempt to assure that the technology will actually do the job it is supposed to do in the field. These are mostly valid and should be addressed during the technology's development and integration phases. Some barriers may be difficult, but they can be overcome. One thing to remember is not all technology is "high" technology. It is not necessarily complex. Technology might be a straightforward application of a simple concept.

Technical Risk

Barrier: Technical risk is always present whenever a technology has never been used before or the application is novel. Will the technology accomplish what is necessary? Will it force us to modify the way we do business? What don't we know? These types of questions characterize the technical risk barriers. Fears of unknown answers and their impact on the weapon system are a major concern.

Strategies: We can reduce technical risk by going the form, fit, and function route. We must focus on prior uses and experiences to help allay the fears. The fact that someone else was first and by showing how our application mirrors the previous use should reduce this barrier to its rightful size. Next, we must identify the similarities and the differences. When the differences are significant, we must cite the risk reduction plan which addresses these differences. A coordinated field test with the users will also help answer some of these questions.

Too "Buck Rogersish"

Barrier: This comes from people who have never heard of the technology before (except perhaps in science fiction movies). It also comes from having nontechnical people making technology management decisions. "Cultural" differences and not understanding the need for the technology are often at play.

Strategies: Education is our only tool to combat this barrier. We need to show how this technology is evolutionary and not revolutionary. We must not overwhelm people with highly technical specialized jargon, but keep the audience in mind. We must also find examples of how others are using this technology in applications closely related to our application. Once educated, these people will often "see" how the technology will work.

Lack of Operational Test Data

Barrier: This encompasses the attitude of "proving it will actually work in the field." Is there an available test bed? Can we use stimulation testing (prove it works in environmental extremes)? Can we fashion a realistic operational test with users?

Strategies: New technology needs to be demonstrated in the context of where and when it will be used. Technologies resolving cold weather problems need to be tested at northern bases during the winter. By making the users part of the test team, we will be able to address their concerns directly and work their suggestions into the production item. Operational tests need to be of sufficient length, not only to obtain enough test data to satisfy the engineers, but also long enough to convince the users that they will benefit by requiring the technology.

Defined Requirement

Barrier: Is there really a need for the technology or is it technology for technology's sake? Do we really know what the users want? Do users know what they want and need? And does this technology really resolve a problem?

Strategies: The strategy is similar to the one mentioned—get the users involved. It is of the utmost importance to tie technology solutions to field problems. This barrier is valid when we are merely trying to do things a new way. We simply cannot afford to change for the sake of change. We need to make the connection of technology solutions to users' field problems. This is especially true when users are not aware of the alternatives. There is a fine line as to who is the driving function, but the result should always be shown as resolving a user problem.

Technology Awareness

Barrier: This is a corollary of the "Defined Requirement" barrier. Do the users know what the alternatives are? Are they aware of existing solutions to their problems?

Strategies: Education helps resolve this barrier. Most users become more than happy to embrace a solution to their problems once they are aware of the solutions.

Different Computers Can't Talk With Each Other

Barrier: With everyone imaginable selling computer systems (hardware and software), we often find two different systems unable to interact or talk with each other. Often this leads to replacing the entire system or doing nothing.

Strategies: As computers become the norm in the business realm, middlemen are developing machine protocols and networking interfaces. Whenever our technology is related to computers (hardware/software), we need to identify and work the computer interfacing problems during the development phase. We should NEVER try to apply the technology without assurances that our computer subsystem can communicate with the entire system. With computers and software, a smart approach is form, fit, and function. We must be sure the technology will work on what the field users have. By applying common standards, we will help reduce software/hardware interface problems. These strategies also apply to embedded computers and software.

Regulatory Barriers

The regulatory arena includes many contractual, administrative, and red tape barriers. Most of these are doable in the sense that we may have to put up with time delays. Or we may be forced into extensive coordination efforts. However, many of these barriers should not simply be revered as unalterable facts of life. The folks in contracting often have techniques and strategies to help us. These people are invaluable members of our team.

Specifications

Barrier: This barrier addresses the need to have the technology meet existing specifications for performance and use. Occasionally multiple layers of hidden specs exist. There may be times when no specification exists which addresses our technology. And lastly, existing specs may not even be realistic or applicable to our technology.

Strategies: The first thing to do is to investigate existing specifications which may apply. We need to find out if there are specific references to existing technologies which would seemingly prohibit using our technology. We also need to get with the owner/writer of the spec to see what their original intent was and whether we can get a waiver or even a change to the spec. Another area is the problem of specifying our technology on a production

contract to assure we get exactly what we need. We may need more than a functional specification. Referring to one vendor's "in-house" specifications sometimes will help identify what we need.

Technical Orders

Barrier: Often users will refuse to participate in introducing a new technology if the technical orders (TOs) are not yet written. There is a similar concern over regulations.

Strategies: Again, homework is necessary before trying to sell our technology. Developmental work should include an effort to also develop the initial TOs for field use. We need to validate and verify (and necessarily change) TOs during operational prototyping in the field. Working as a team with field operators will go a long way in dissolving the barriers centered on the users' administrative concerns. One successfully used method is making our technology application transparent to the users. Then the field level TOs should not require changing.

Authority to Change

Barrier: Often people will throw up the barrier of "Do we have authority to change what is?" Do we own the technology being changed, or do we own the equipment being changed? Who owns the TO? Have we coordinated this with all the right offices? There is a people version of this which I will discuss in the next section, "People Barriers."

Strategies: If TOs and regulations apply, it is imperative to work up front with the owners to make them team members. We need to identify the benefits they will accrue when our technology is employed. Authority to change is implied in everyone's job. All employees need to improve existing systems and methods when these advancements will address the R&M 2000 goals.

Sole Source

Barrier: This barrier addresses the contracting requirement of additional paperwork when there is one, and only one, qualified source of the technology. The Air Force's Competition Advocate's office requires written justification for sole source procurements.

Strategies: The rhyme and reason behind this barrier is admirable in its attempt to keep procurements open to all qualified vendors. However, in the new technology arena, many technologies have been developed by a specific contractor under Independent Research and Development (IR&D) or Contracted Research and Development (CR&D). Thus, there may only be one qualified vendor for the first-time procurement. Because of the "Not Invented Here" barrier (see "People Barriers"), a single vendor may be the only one qualified for follow-on procurements. Justification waivers can, and should be, written. Unfortunately, they take time. If we begin working early with our contracting folks, they will help us write the justification when the justification makes technical sense. The law does provide for waivers, so we should learn the whys and wherefores and use them wisely.

Procurement Lead Time

Barrier: This is an extension of the previous barrier. If we do not regularly live in the contracting world, we can easily be overcome by all the rules and regulations which seem to be nonsensical roadblocks. For the most part, they exist to address past abuses of the system and to assure that we actually get what we want, when we want it, and at the predicted cost. These "roadblocks" include sole source waivers, statements of work, requests for proposals, source selections, best and final offers, and negotiations. Each of these takes time and usually cannot be done concurrently.

Strategies: Once we realize these contracting steps are in place to help us, we will better appreciate the reasons why some take so long. We can help ourself, by learning about contracting, by planning ahead, and by developing a close working relationship with our contracting folks. When necessary and appropriate, they can help us use some shortcuts to reduce procurement time. These barriers do not necessarily have to be facts of life either. If we believe these barriers are merely there to thwart us, we can challenge the contracting system (in a nonthreatening manner, of course).

Diminishing Dollars

Barrier: Diminishing dollars will always be a fact of life. High acquisition costs and no operational test funds are often cited as reasons why our program will remain less than complete. Sometimes single year money causes a problem. In the support community, the type of money (developmental versus support) and who has the authority to spend it can be a barrier. Sometimes a low bid does not guarantee the lowest life cycle costs.

Strategies: The best way to get, and keep, funds is to have a well-thought-out program which anticipates many of the issues and addresses those concerns up front. People are more willing to spend money when they understand what is going on and what their benefits will be from their efforts. Again, we must get our boss's customer, the user, behind us. Often, in development, smaller steps, rather than the whole nine yards, offer a higher degree of success. This is especially true when money is single-year money. We must be sure the various program steps are integrated so each step follows the previous steps. This minimizes the "Procurement Lead Time" barrier. When retrofit or production money is tight, preferred spares is one method of introducing the technology. Many of the other regulatory barriers are reduced when we have obtained the technical data for future follow-on procurements.

Vanishing Vendors

Barrier: This barrier occurs when businesses no longer sell certain products. As technology advances, old technology tends to become outdated, especially in the electronics arena. Commercial businesses create markets in areas where there is a future and a profit. Hence, businesses tend to drop product lines when the demand is low, especially when there is only a sole customer. It then becomes cost prohibitive to keep limited vendors with limited product lines in business. Sometimes people consider "Vanishing Vendor" more of a driving force than a barrier. I have included it in the regulatory group of barriers because it is often a situation the Air Force faces. The usual solution entails throwing more and more money at the problem just to keep old technology production capability.

Strategies: In this situation, newer technologies can replace older ones. Often form, fit, and function constraints can be used. It is important to keep as many vendors qualified as possible to keep multiple sources of supply and competition. This may entail educating other businesses, sharing manufacturing processes, and qualifying new vendors. We must obtain data rights. Contractual mechanisms such as functional data item descriptions often provide sufficient information for remanufacturing or reprocurement.

People Barriers

People barriers are those barriers behind which people tend to hide when they do not have any technical or regulatory reason to block technology. These barriers often take on the characteristics of a technical or regulatory barrier. If, as we work to resolve those aspects, they continue to throw more barriers in our way, we will see people becoming blind to our efforts. It is time to look beyond the facade of the barrier. We must assure ourselves that the real barrier is not actually a people barrier in the sheep's clothing of a technical or regulatory barrier.

Unfortunately, these barriers are the most difficult to overcome. People's lack of any firm reasons or facts justifying the barrier causes this difficulty. They have attitude and perception problems. The only strategy for overcoming these people barriers is perseverance, a well-thought-out game plan,

and the ability to show these people that they will benefit by being part of the technology transfusion team.

Lack of Awareness

Barrier: This barrier is when individuals in the decision process are simply not aware of a technology's capability. Technology advances occur at such a rate that most of us are too busy doing our own work to keep current on all the latest advances of technology. Some technologies advance so rapidly that they are out-of-date before they are fielded.

Strategies: Education answers this lack of awareness. Education can take many forms: participating in technical society conferences, reading technical journals and magazines, regularly reviewing databases like the Defense Technical Information Center (DTIC) and the Defense Logistics Studies Information Exchange (DLSIE), attending technology briefings and demonstrations, and reading the AFCOLR'S TechTIPs. Once these people recognize they are behind in education, they usually respond to our education efforts. They become technology-literate.

Too "Buck Rogersish"

Barrier: This is the people version of the technical barrier of the same name. These people are not only technically unaware, but also wish to remain in the dark. They are usually limited by their lack of technical savvy, and most new technologies are simply beyond their comprehension. They also may be afraid of additional workload, especially if the workload appears to be different from what they are comfortable with.

Strategies: We need to provide an education by the technical experts. We should require the users to loudly present their requirements for the technology. Then, we should show the long-range payoffs to this foot dragger.

Perceived Technical Risks

Barrier: This barrier is characterized by people's lack of knowledge about the previously demonstrated technology successes. Or, more accurately, it is lack of belief that the technology will work on their system, even though it was previously demonstrated.

Strategies: We need to develop a test plan which will include this doubter and the field users. We must show that we are addressing all their concerns in our prototyping plan. The best approach is to have the users of the previously demonstrated technology advocate its use to our users.

Too Much To Do

Barrier: This is another way of people saying, "I'm too busy...too many things are stacked up right now...don't have time to look at anything new!" They believe that anything new is of low priority. Hence, they do not want to hear about it. After all, they may have to take some action!

Strategies: Good managers are always busy. Their time is precious. This is an excellent opportunity for the boss's customers, the field users, to rattle some cages. If technology will help solve the users' problems, it is time for them to stand up and be counted. Good managers will always make time for their customers, especially when they see that they will come out ahead.

No Authority

Barrier: This barrier features the individuals who refuse to stretch beyond what their predecessors had done. This looks very much like the regulatory barrier of the same name, but usually is identified by its unique flavor of their desperation to stop our technology application. This is usually their last gasp attempt to scuttle our efforts by hiding behind bureaucratic red tape. If we listen closely we will hear them proclaim, "Without authority, I have no responsibility!"

Strategies: We can begin by acknowledging that, "Yes, there is no regulatory authority specifically giving you responsibility or permission to apply this technology." But quickly follow that with, "There is also no regulatory authority prohibiting you from...!" We should show that our technology's application will improve the world and wipe out the government's deficit. If they still do not come around, we might want to gather together our technology transfusion team and go visit their bosses. This is probably one of the few times that going around the chain of command is necessary. However, we must be careful not to burn our bridges behind us. Tact and diplomacy count immeasurably.

Negative Opinions

Barrier: These people have seen an earlier version of the technology which may have had problems. Or they have heard someone else say some nasty things about the technology. Old information and second-hand knowledge are dangerous.

Strategies: Education is again our partner in success. Innuendo is hard to debunk. Our technical credibility will help immensely. We must show these people how the technology has changed and improved over previous versions, and how we are addressing the causes of the previous problems. It may be necessary to discuss the differences between our application and the previous ones. We must not forget to address the perceived technical risks of this different application.

Technology for Technology's Sake

Barrier: These people believe that engineers are constantly pushing technology for technology's sake. They also want someone other than themselves to be the guinea pigs.

Strategies: Users are our biggest ally in educating people to see our technology application as answering their needs/requirements. We need to demonstrate the benefits to the users.

Education and Re-education

Barrier: Because not everyone is technically astute about our technology, we will constantly be put in the position of discussing application with those people who simply do not understand. This barrier also refers to the management merry-go-round where the hierarchy is constantly changing. As new people come aboard, they have to be brought up to speed on the details of our technology application.

Strategies: The methods may be time consuming but necessary. Our success depends upon the knowledge of those above us. When new people come in, they need to be educated. However, we should not reinvent the wheel each time. We need to have a well-prepared briefing on the shelf. Also, we should prepare a complete information package with a listing of all major players on our technology transfusion team. It should include a concise talking paper about what we are trying to accomplish along with the benefits. Then, we should be ready to elevate the issue if our management team looks like they are playing musical chairs.

Lack of Operational Data

Barrier: This people version of the technical barrier centers on the belief that technology will not be successful unless we prove beyond a shadow of a doubt that our application will work. This shadow may well put a total solar eclipse to shame. These folks are never satisfied with the data we collect from the field. As we present them with one set of data, they will ask for more and more. Sometimes they want to have as much field information on the new technology as they have on the old.

Strategies: We will never have as much field data on new technology as we do on the old. Usage experience is nice, but it will always be limited for new applications of technology. By including these people early in our test plans, we may nullify their complaints. We need to provide them with warm fuzzies. We must find out what it is they need to see and try to get a memorandum of understanding along with an agreed-to-definition of what constitutes a field success.

Not Invented Here

Barrier: This syndrome focuses on ego and self-fulfillment. This barrier is often cited about vendors and what they offer. After all, their profit margin depends upon them selling what they have invented/developed. Rather than admit that their company's bottom line is the forcing function, they hide behind the belief that their technology is superior to everyone else's. They will use every other barrier in the book to induce us into using their technology approach.

Strategies: The best method of overcoming this barrier is competition in the open market. We must have strong requirements with a firm idea of the results we want. Of course, flexibility is a must because we may find alternative solutions coming forward which are better than our approach. If we are inflexible, we too may be guilty of this people barrier. Remember, the users' supportability is the bottom line, not the application of a certain technology, or a specific vendor's technology. The flip side is being able to agree on the "best" approach for the field and then pressing forward together.

Training

Barrier: This is really a technical barrier more than a people one. But because it is centered on the people part of the equation, I have included it. This barrier basically entails, "How do I use the technology in the field and how do I maintain it?"

Strategies: This valid barrier needs to be addressed early in the program and worked closely with the users during the operational testing phase. Training is not only for the field users, but also for the depot repair folks and management. It is imperative that people using our technology know the "how to." It needs to be user-friendly, concise, and written (don't rule out other media) in a language the users readily understand. As I stated earlier under TOs, we must strive to make the technology transparent to the users. Whenever they can accrue the benefits without changing their ways, we gain a close ally.

Lack of Team Effort

Barrier: People characterize this barrier by wanting to do the whole project by themselves. The convenience of working alone is offset by the lack of enthusiasm by other agencies for our project. Some offices prefer not to be team members. Their performance ratings usually come from a home office not directly related to the project. Or worse yet, the job becomes a low priority relative to all their other responsibilities.

Strategies: The first and foremost strategy is to form a technology transfusion team, even if it is an informal team. No one person can go it alone, especially if we are depending upon contracting and user folks to help us through the other barriers. It is important to define each individual's responsibilities in making our team's application successful. We should address the needs and desires of all people and make them feel important and valuable to the team...because they are! We should also demonstrate how success depends on each of them. If we can gain authority over their performance appraisals, great. If not, the power of the written word to their boss's boss on their successful performance will do wonders.

Ten Rules for Success

After reviewing all the barriers, the reasons they exist, and strategies to attack each barrier, let me summarize them into Ten Rules for Success. Even though these are general in nature, they certainly will help Air Force personnel reduce the barriers into conquerable objects and reduce anxiety to a level of peaceful coexistence.

(1) - Plan Ahead

This is the first step of any successful venture. Look down the road and anticipate the barriers. Once anticipated, address the game plan for each barrier and show how to minimize each one.

(2) - Fit the Technology to the System

This is the homework session before actually trying to sell management. Understand how the technology applies to the weapon system or subsystem and how it will provide benefits to the weapon system. This also includes identifying the drawbacks of using the technology.

(3) - Demonstrate How Risk Is Reduced

Remember, the performance of bosses is directly related to their being able to be either very lucky or being able to make smart management decisions which do not force them to constantly stick their neck out. Show how prior use of the technology actually reduces their risk (and hence, their anxiety).

(4) - Sell the Economic Benefit

Everything new costs money—money which is competing with other priorities. Show how this technology application will save money or avoid future costs. Do appropriate life cycle cost analysis. Show how the maintenance burden will be reduced. And, when applicable, show how the customer will be more satisfied by using the technology.

(5) - Involve the User

The customers become more of an advocate when they are consulted from the start. Make them an integral part of the team. Use their input to fashion the technology into something with which they can identify. By all means, prototype the technology on one of their systems. With them, learn the pluses and minuses. Lessen the impact on the field folks. If at all possible, make the technology transparent to them. But at the same time, make their benefits large and direct.

(6) - Remember that the Contracting Department Is Your Friend

Work with the folks who will contract out the development or buy the final product. These folks can help strategize the way through multiple regulations and requirements. Paperwork is their forte. Help them understand goals so they can better serve everyone.

(7) - Be Credible

Truth and honesty, with a touch of sincerity, go further in helping sell the perspective of why this technology is the best thing since sliced bread. Don't oversell the capability or the schedule. Discuss the drawbacks as well as the benefits. The bosses' time is precious. Help them use it wisely by developing their trust.

(8) - Be Flexible

Not everyone will share the vision of the future. There may even be times when people will offer advice which will improve the application of technology. Listen to them and include their changes when it will make the application better. A word to the wise—be careful when reminding hesitant bosses about their "flexibility."

(9) - Be Persistent

Without being a pest constantly at the boss's doorstep, stick with a vision. This can be renamed, Believing in the Proposal. Believe that this technology will solve the customer's problems, that it has more benefits than drawbacks, and that it will save money over time. Then sell the technology. Persistence will help management have the same vision.

(10) - Be Creative

There are a million alternative solutions to every problem. Ignore barriers. Level of control is directly related to the creative visions on how the barriers are subservient.

Conclusion

The barriers do exist. And there is no question they represent a challenge. Each barrier needs to be addressed in context of Air Force technology and its application. I certainly do not advocate simply skirting around the barriers or ignoring them completely. They WILL come back to haunt us somewhere downstream. Even though we see them as our enemy, some barriers make sense and are there for reasons of checks and balances. We must keep in mind our goal of improving supportability of the weapon system through application of new and existing technologies. There are many questions to answer. Addressing them head-on will help us complete tasks successfully.

There are barriers, however, which may make no sense whatsoever. These are the ones we should challenge. Challenging these barriers and their keepers (in a positive fashion) will help us become successful in technology application. And, finally, we must work to change those barriers which need to be changed...even if it is not a responsibility of our job.

The biggest secret to success is COMMUNICATION. This entails both talking and listening. Technology application depends upon many folks from different organizations. We should realize that there may be language, cultural, social, and educational differences between the researchers, developers, contracting officials, and field users. They each have their own objectives and goals. We must avoid the trap of stereotyping folks from different agencies. The more they know about us and our technology application, and the more we know about how they operate and what their needs are, the more probable our success will be.

Everyone should share the same performance standard of making "SMART" decisions, not "SAFE" decisions. Just because the Alligator in "POGO" was right, does not mean we should allow observations of the past to be the rules of the future.

51st Tactical Fighter Wing Needs Help in Writing History

The historians for the 51st Tactical Fighter Wing have been tasked to write a companion volume to a history of the 51st which details its conception, World War II, and Korean Conflict activities. The initial volume used many "first person" quotes, and they would like to use that same format for this companion volume which will discuss the 30 years from 1959 to 1989.

In order to use those "first person" quotations, the historians need to be in contact with men and women who have served with the 51st and its assigned squadrons at Naha AB, Okinawa, Japan (between 1954 and 1971) and Osan AB, Korea, and the other Korean bases which served as home to 51st squadrons, like Suwon and Taegu, plus any others which might have been used from 1971 to present.

They are looking for photographs as well as memories with which to illustrate the book. There have been many squadrons assigned to the wing at different times, and they hope to hear from people who were part of the 51st—no matter what sort of job they had. They would be just as interested in hearing from fliers as non-fliers, from cooks as well as civil engineers, and from mechanics as well as medics. They would like to produce as well-rounded a work as possible.

If you can help with this history, please contact MSgt Christopher B. Scharping, Wing Historian, 51st Tactical Fighter Wing, APO San Francisco 96570.

SOLE Logistics Symposium

The 24th Annual International Logistics Symposium sponsored by the Society of Logistics Engineers (SOLE) will be held August 31 - September 2, 1989, at the Hyatt Regency Hotel in San Francisco, California. The theme of this year's symposium is "Defense and Commercial Logistics—Seeking Solutions." D. Travis Engen, CEO of ITT Defense Technology Corporation, will be the keynote speaker. For information call Patricia Sutherland at SOLE Headquarters (205) 837-1092.

Most Significant Article Award

The Editorial Advisory Board has selected "The Unsung Heroes of the Air Logistics and the Air War Over Europe, 1941-1945" by Robert P. Smith as the most significant article in the Winter 1989 issue of the Air Force Journal of Logistics.

Inside Logistics

Exploring the Heart of Logistics

CASC Early-on Involvement in the Acquisition Process

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Do you know of any acquisition programs that would benefit from the following, especially since they are freebies?

BENEFITS:
Cost savings from:
- **Eliminating unnecessary research & development**
- **Providing better quality lists such as bulk items, electronic support equipment, and hand tools**
- **Eliminating stocklisting of new items when items already exist in the inventory**
- **Eliminating the need to train personnel on new equipment**
- **Eliminating the need for new operation and repair manuals**

Reduced production and delivery lead times

Improved supportability, reliability and maintainability by using items with proven records

Enhanced competition in procurement by identifying additional sources for items of supply

CASC Services

The Air Force Cataloging and Standardization Center (CASC) is in a unique position to assist in providing these benefits. An AFLC organization of 468 people, CASC is located at Battle Creek, Michigan, performing the following services:

Item Entry Control

Controlling the number of items entering the DOD inventory and reviewing existing items in the inventory to identify duplicate items of supply. The objective is to maintain the best spare parts support for weapon systems by using existing standard and preferred items already in the inventory as much as possible. In terms of items proposed to enter the inventory as the result of an acquisition, this means having the equipment specialist (ES) compare the characteristics of the proposed item with available Air Force and DOD assets. The ES then determines whether an existing item can be used.

Review of Technical Data

Reviewing data for item identification and standardization requirements (form, fit, and function) in accordance with MIL-STD-1561, DOD Provisioning Procedures. We also analyze engineering data for adequacy, completeness, and conformity to contract and DOD requirements (DOD-D-1000 and DOD-STD-100). This review helps the AF obtain an optimum data package for the system and follow-on support.

Assignment of Item Name and Federal Supply Classification (FSC)

Grouping items in a systematic arrangement based on common, related characteristics. This serves several supply management needs such as standardization and assignment of the item manager.

CASC now performs all these functions after production contract award in conjunction with provisioning (see Figure 1, Timeline). Moving from a previous post-provisioning mode to the current preprovisioning mode has given the Air Force some gain. However, far more benefits will accrue by moving the same functions back into the demonstration/validation and full-scale development time frames.

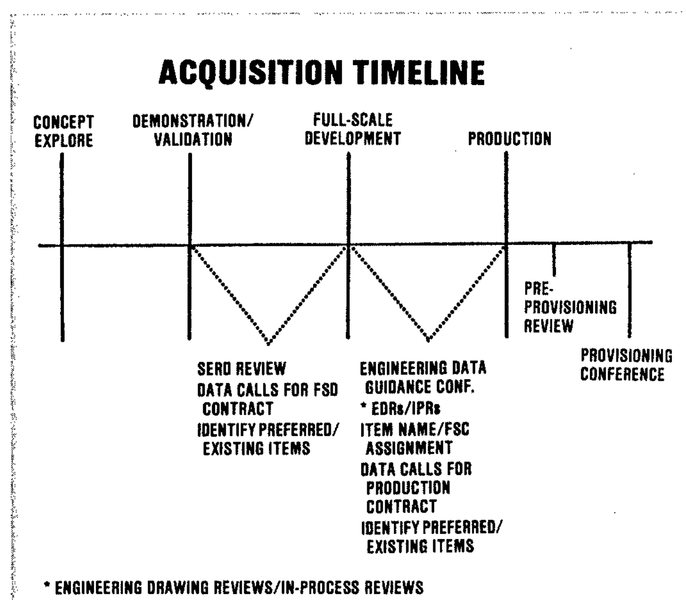

Figure 1.

Programs and Projects

We are experimenting with specific programs, projects, and actions to determine how we can provide the best support. For example:

Small Intercontinental Ballistic Missile (SICBM)

Since September 1986, CASC and the Air Force Systems Command (AFSC) Ballistic Missile Office (BMO) have been working to get early involvement of cataloging and standardization in the acquisition process of the SICBM. We reviewed the 1200 common hand tools on the SICBM tool list and found that 732 (62%) were not preferred items. Specifically, 602 stocklisted items could be substituted for 775 proposed non-stocklisted tools, thus preventing all the costs involved with bringing these new items into the inventory. An additional 130 stocklisted items were found to be preferred over 414 proposed stocklisted tools.

Action is underway to link the BMO Logistics Support Analysis (LSA) database (BMO-STD-77-6A) with CASC via the Logistics Management Information System (LMIS) at Ogden Air Logistics Center, Hill AFB, Utah. By using Z-248 computers, we will receive the SICBM Logistics Support Analysis Record (LSAR) E and H Sheets (Support Equipment and Provisioning Parts List), make recommendations, and transmit this information back to the database. This process will be expanded to the Rail Garrison Program.

The E sheets (Support Equipment Recommendation Data - SERDs) will be reviewed to ensure accuracy and completeness of the information. When BMO receives this data from ASCONs (Associated Contractors) for formal coordination, we will review them first so our recommendations for support equipment will be visible to all subsequent reviewers as preferred/standard items.

The H sheets (Provisioning Parts Lists) will be reviewed for:

- Item Name and Federal Supply Classification (FSC)
- Item Entry Control Data (stocklisted items, preferred parts, alternate sources) as soon as the lists enter the data base
- Technical data adequacy

We were also involved early in this acquisition by reviewing the Electronic Support Equipment List, Support Equipment Commonality List, and the Bulk Items List.

C-17

CASC is involved in the acquisition of the C-17. We attended an in process review (IPR) of engineering data to assist the Engineering Data Management Officer (EDMO). The purpose of IPRs is to ensure the contractor is meeting contractual obligations to the Air Force. Our participation has been beneficial to both AFSC and AFLC.

We attended a Technical Interchange Meeting (TIM) at the contractor's site. The purpose of this joint Government and Industry meeting was to provide an exchange of ideas and technical expertise between the aircraft manufacturer and the Air Force with the goal of providing optimum support of the aircraft. One concern was to ensure the use of Government Furnished Equipment as much as possible. Another was to ensure the most preferred items were being identified by the contractor for support equipment and to avoid proliferation of items in the inventory.

We are supporting the C-17 program with participation in the Resident Integrated Logistics Support Activity (RILSA). An ES and a senior supply cataloger are permanently assigned at the contractor's facility, Long Beach, California.

B-1B

Review of the B-1B Tool List provided by the contractor determined that 1304 (33%) of the 3900 items no longer existed. Standard items were offered as replacements.

Tiger Tool Team

We are working with the HQ USAF/LEY chartered Tiger Tool Team (T^3) to prepare a listing of tools which will be part of the Support Equipment Acquisition Management System. These tool lists are to be used to influence design of future weapon systems/aircraft so one tool box can be used on all systems. This will avoid proliferation of unneeded tools in the supply system and, more importantly, on the flight line.

Data Call Review

A data call is the formal procedure used by the data management officer to identify the data requirements for a given contract, program, or project. CASC identifies requirements that are applicable to the mission and makes other recommendations. One major requirement is to ensure that support equipment illustrations (SEIs) are bought on all support equipment contracts. This information is used to load the MIL-HDBK-300 Technical Information File (TIF). Another is to ensure that CASC is included on the Contract Data Requirements List for delivery of supplementary provisioning technical data.

Engineering Data Guidance Conference

We are beginning to attend engineering data guidance conferences. This is a comfortable environment for us because it is an extension of our daily workload.

Moving into the earlier acquisition stages is a natural flow for cataloging and standardization, as well as an exciting challenge to our organization.

AFOTEC and Logistics

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What is AFOTEC? Headquartered at Kirtland AFB, New Mexico, the Air Force Operational Test and Evaluation Center (AFOTEC) is a separate operating agency that reports directly to the Chief of Staff, USAF (CSAF). AFOTEC manages the overall USAF operational test and evaluation (OT&E) program and conducts tests on newly acquired major USAF and DOD weapon systems, communications systems, space systems, and munitions. It also monitors all MAJCOM-conducted OT&E such as that performed by Tactical Air Command (TAC) on the F-16 Air Defense Fighter. AFOTEC is independent from acquisition or operational commands, and its reports convey performance results in a timely operational environment for CSAF and Office of the Secretary of Defense (OSD) acquisition decisions.

The AFOTEC Logistics Directorate is the hub for testing the logistics suitability of new weapon systems ranging from avionics on TAC fighters, to the B-1B, and on to the space shuttle. To accomplish this mission, we have 108 aircraft/munitions/communications maintenance and software engineering personnel and logistics analysts whose job is to plan and execute the logistics portions of all operational test and evaluations. AFOTEC's loggies come from every operational command. We pursue the maintainability, availability, and reliability portions of all new weapon systems and whether these systems can perform their combat missions from the logistics perspective. AFOTEC's bottom line is to get the "bugs" out of new weapons before they are given to the operational units, with a resulting increase in greater reliability, maintainability, and overall greater combat readiness for all forces.

USAF Logistics Policy Insight

OSD Policy on Munitions Items

In January 1988, the Office of the Secretary of Defense (OSD) implemented a new policy on when a munitions item may be included in the President's Budget request to Congress. The policy, which was reaffirmed in November 1988, states that an item may be included in the budget only if it has been "Approved for Service Use" prior to submission to the Congress. The terminology "Approved for Service Use" has been interpreted by OSD to mean that the item has been authorized for production. Since this policy may cause deployment delays if a munitions item's schedule does not coincide with the budget cycle, the Air Force and other Services requested the Defense Acquisition Board's Conventional Systems Committee (Munitions) reexamine this issue. The Committee convened in May and will make a final decision this summer. (Mr Frank Jones, AF/LEXP, AUTOVON 227-3119)

Logistics Information Integration

As information systems transition more rapidly from data storage systems into decision support systems for managers at all levels, the logistics community must develop a broader view of the total information needed to do its jobs. It must also be more attuned to the logistics information needs of commanders at all levels of our fighting forces. Our perspective must include base-level, major command (MAJCOM), and wholesale logistics worldwide. Integrating logistics information within itself and with other critical information is becoming a high priority. A new organization, the Information Systems Division, has been formed to assist in and accelerate this process. As information systems are developed or changed, the functional integration aspects of the systems will be considered during the approval and oversight process. Much greater attention will be placed on understanding data management as an essential integration method. To make this policy of integration a success, the users of these systems must provide continued help throughout the ongoing process. Please call the functional representative in the Information Systems Division with any questions, ideas, and recommendations. (Col John Moran, AF/LE-I, AUTOVON 225-1015)

Technical Brief on the TAAF Process

Recently, with the Air Force as lead, a tri-service (Army, Navy, Air Force) technical brief, "The TAAF Process, A Technical Brief for TAAF Implementation," was published. The Test, Analyze, and Fix (TAAF) process is a closed-loop reliability growth methodology designed to identify, analyze, and correct failures early in the design phase, thereby allowing maximum reliability growth. Preparation of the document stems from concern over a common problem pervasive in military acquisitions: the lack of uniform discipline and rigor in planning and executing a TAAF program. The technical brief provides the methods most likely to result in a successful TAAF program. Program management methods, engineering practices, and suggested contract language for the program manager and engineer are included in the publication. (To receive small quantities of the brief, or for information on how to arrange large printings, contact Major Doug Grant, HQ USAF/LE-RD, AUTOVON 225-9836.)

Combat Ammunition System

The Combat Ammunition System (CAS) is a reality! The system is up and running at several overseas locations and at the Air Force Ammunition Control Point at Hill AFB, Utah. New installations are ongoing throughout the Air Force. Over the next four years, we will install 90 mainframe computers and 205 satellite connections to automate munitions (conventional and nuclear) logistics management worldwide. CAS is the Air Force's number one priority automation program—it is a major element in the USAF Logistics Command and Control Network and will provide commanders at all levels with accurate, timely munitions data. CAS will greatly enhance combat capability by optimizing peacetime munitions posture and by giving combat commanders information they need to employ munitions resources effectively. The AMMO troops in the field are the key element in making CAS a success—they can effectively learn CAS duties and do them right. Then their job will be easier and the Air Force will be more combat ready. (Major Pat Thayer, AF/LEYWN, AUTOVON 227-0771)

AFR 77-7

The Air Force transportation community has undertaken a major initiative to improve the suitability and reliability and maintainability (R&M) of key vehicles. Its goal is to provide vehicles that will more closely suit the user's needs and provide higher operational readiness rates through better engineering design and simplified maintenance requirements. Transportation plans to achieve these results through increased use of state-of-the-art automotive technologies and improved R&M techniques. As further enhancements to this effort, it is publishing a formalized methodology for determining user requirements (as covered in the upcoming publication of AFR 77-7, *Vehicle Performance Requirements Process*) and

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Technological Trends and Logistics: An Interrelational Approach to Tomorrow

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The influence of new technologies on society has been so all-encompassing that an analysis of their impact on logistics cannot be limited to the obvious. Scientific discoveries and daily events that may seem diverse and unrelated to logistics and to each other are, in truth, part of the complicated and complex network of concerns which affect how we must approach the future. This paper analyzes various technologies and their impact on logistics.

Introduction

Economist John Maynard Keynes once wrote: "The inevitable never happens. It is the unexpected always." Projecting the future, as Keynes suggested, is risky. Even when an analysis of tomorrow is based on the solid facts of today, the economy, a new discovery, politics, and hundreds of other factors can turn a well-reasoned prediction into a lousy guess. Who would have imagined a device that could endlessly copy printed matter would change the way we do business forever? Chester Carlson, the inventor of the photocopy machine, which is better known under the brand name Xerox, was told by business that his invention was unnecessary because libraries and carbon paper already filled that need. Here was a technology that drastically changed the way people approached information, yet Carlson had a hard time finding a listener, much less an investor.

Instruments for change, as apparent as they may seem once implemented, often elude our understanding before they enter the mainstream. In order to better evaluate the impact that technological changes may have on our profession, we are forced to look at trends in diverse disciplines. Only by discerning the interconnectedness of these trends can we even begin to glimpse their exponential ability to alter the work we now do. However, the task grows more difficult as national concerns give way to international concerns and the amount of information available to us grows beyond our ability to deal with it, except in the most superficial fashion.

The Wall Street Journal reports that at least 40,000 scientific journals are published yearly, producing about a million articles. Experts estimate that the output of scientific literature doubles every 10 to 15 years and point out that one of the culprits is the computer which allows both desktop publishing and electronic dissemination.[1] Even in the availability of information, technology has both benefited and hindered us in our quest for knowledge.

Putting Technology in Perspective

We are daily bombarded with announcements of scientific discoveries that border on the fantastic. Information which may have a lasting effect on our business, not to mention the quality of our lives, comes from all quarters. During personal research, I developed a matrix* which listed 93 technologically-based products, or approaches to technology, culled from the "Science and Technology" section of *Business Week* over a seven-month period covering parts of 1987 and 1988.[2] I included developments in eight technical areas, their possible impact, and the time at which they were expected to be commercially available. I also included the primary logistics area which might be affected by a particular development. From this interrelational matrix, I began to discern the complex network of developments and trends which must be anticipated and managed if we are to be prepared for the next century:

(1) While the vast majority of the 93 inputs were developed in the United States, the information was extracted from an American magazine. In checking foreign news sources, many of the items listed were also being developed abroad. Foreign competition and technology transfers are issues that will be hotly debated now and in the future.

(2) A surprising number of US companies developing and producing new products were newly established, were small (sometimes only one or two people), and were still seeking funding to further underwrite their enterprise. What this may mean in terms of finding the best product for a program, ensuring that it will be available when needed, and having the ability to influence its refinement is yet to be seen.

(3) There have been many reports in the press of cuts in Research and Development (R&D) monies. A little over one-quarter of the matrix entries were available although some of them were expensive and were not widely used. The remainder ranged from being no more than a good idea to products or services needing little more than a final polish before release. In any case, R&D funding is more important than ever.

(4) National and private labs were listed 10 times as opposed to 18 entries for universities. Educational institutions and business will soon be linked more closely than ever.

(5) No one innovation can be considered in isolation. For example, superconducting IC chips may lead to faster, more

*If readers would like a copy of the matrix, they may contact the author. Please send self-addressed stamped envelope.

powerful computers which can be used to automate factories. More information will be analyzed and used to develop new products from new materials which will necessitate changes in how we, as logistics engineers, support a system.

Logistics and Technology

The traditional definition of the logistics system is that it is the mechanism by which food, transportation, and spare parts are supplied to military forces. But, over the years, logistics has evolved and now touches on many areas of support and, in turn, is itself affected by developments in many industries. Training, Reliability and Maintainability (R&M), Maintenance, Testing, Software Supportability, Transportation and Distribution, Packaging, Computer Aided Logistics, Integrated Logistics Support, Spares, Provisioning, and Manpower are some of the areas that would show up on any checklist of logistics concerns. The tasks which comprise the field of logistics, and the manner in which they are carried out, are heavily influenced by the technologies which they must support.

A report prepared by the National Bureau of Standards and the U.S. Department of Commerce, "The Status of Emerging Technologies: An Economic/Technological Assessment of the Year 2000," identifies seven emerging technologies which are believed to be critical to the future US economy.[3] For the purpose of this paper, the technologies identified in the study will be analyzed for their impact on logistics. Special emphasis is given to Automation and the Computer. One additional consideration is added: Human Factors. Because technology does not develop in a vacuum, those social forces that have an effect on how new developments are implemented are also discussed at some length.

Automation

Computer integrated manufacturing (CIM), flexible systems, robotics, and new approaches to manufacturing needs, such as "Just in Time" (JIT) deliveries of materials, influence how the US will compete internationally and how the work force will be comprised. They also directly impinge upon many other areas which determine how we will do business in the future.

Automation is not a new idea and science fiction writers have used it as a vehicle for a number of stories. In fact, many of their fantastic tales have proved truer than the predictions of scientific experts. In 1952, Kurt Vonnegut, Jr., wrote a fictional account of a city in the future where people have been replaced by machines. Vonnegut relates the story of some young engineers sent to encode the motions of a human at work:

> The foreman had pointed out his best machinist . . . the three bright young men had hooked up the recording apparatus to his lathe controls. Now, by switching in lathes on a master panel and feeding them signals from the tape, Paul could make the essence of [the machinist] produce one, ten, a hundred or a thousand of the shafts.[4]

Vonnegut did not have things entirely wrong—automation *is* eliminating many jobs—but the human approach to a task has given way to new design techniques which accommodate robotics rather than echo procedures used by warm-blooded, two-handed creatures. Parts and modules are being designed for maximum simplicity and increasingly are meant to be thrown away when they fail. The tradeoff for disposability is increased reliability. With the elimination of extra parts and operations comes lower costs and, for the logistician, fewer part number assignments, spares purchases, inventory and storage requirements, and less testing and inspection. Manpower availability becomes less of an issue, both on the assembly line and in the maintenance and repair field. In fact, fewer designers may be necessary as robotic engineering parameters are built into the computer aided design (CAD) software.

While a product may last longer than previously, it still is inevitable that it will break or fail at some point. The logistics engineer must ask: Can we accept battlefields strewn with damaged equipment, abandoned because it cannot be repaired? Do we remove it from service at some predetermined point, working or not, rather than risk having to deal with disposal at an inopportune moment? Perhaps aging, working units should be used in training, or new robotic techniques for refurbishing should be devised. As new products come along, these questions among many others have to be dealt with, not when the item is in use, but in the idea stage.

New manufacturing techniques have made as much of an impact on production redesign as they have on product design. The Flexible Manufacturing System (FMS) is a concept which includes the ability to reprogram an automated system (rather than retool) to accommodate new products. Presently, refinements in the equipment necessary for FMS, lower startup costs, and a better understanding of how the system must be managed are all necessary before it is commonly accepted. Although FMS has been slow to catch on, it seems clear that the equipment can only get better and its cost lower. The biggest roadblock, then, is how to handle the system.

For the Logistics Engineers who must concern themselves with quality and adherence to specifications of the products being manufactured, "handling the system" will evidence itself in a number of ways. One is the methodology by which parts and units may be chosen. The only way to judge the acceptability of an item is by seeing if it meets the specifications and standards which define it. Those standards will increasingly be encoded in software and the logistician of the future will have to ensure that the software which carries the manufacturing directives meets some predetermined specification itself. Logistics engineers may soon find that computer courses are not only beneficial, but absolutely essential.

Another response to FMS and automation in general is the program phase at which the logistician must become involved with the product. A management philosophy which has been gaining increasing acceptance is Mechatronics, or simultaneous engineering. Mechatronics integrates product design with manufacturing demands and involves teams of personnel from many different departments working together from the very start of a project. Logistics engineers must begin to express their concerns as early as the idea stage of a program. In fact, immediate involvement in the development of a product may not be optional. The concept of simultaneous engineering has been taken to heart by the Pentagon.

Realizing the need for influencing and checking systems at the prototype stage, Air Force Systems Command's Electronic Systems Division (EDS) has established a "readiness

improvements through systems engineering" program known as RISE 2000. Called a "back-to-basics" approach by Lee Pollock, Director, ESD Systems Readiness Engineering Office, RISE has simplified the tasks that define the reliability and maintainability of a finished product.[5] An article in *Business Week* pointedly notes, "As many as one-quarter of American factory workers don't produce anything; they simply fix other workers' mistakes."[6] R&M, obviously, is going to be taken very seriously in the future.

Another area of logistics which will undergo change as a result of FMS is Provisioning and Spares. The Navy has instituted what it calls "rapid acquisition of manufactured parts" (RAMP), a computerized manufacturing system designed to produce critical spare parts in small quantities. RAMP allows the Navy to create parts no longer in production. The Navy hopes to expand RAMP to include a reverse engineering capability which would permit technical data to be reconstructed from sample hardware.[7] Tomorrow, warehouses may well hold data rather than parts. If the Navy's idea expands—and it is entirely possible it will—inventories of spares will be encoded in software, drawings, and specifications. Parts on demand may increase the logistician's job manyfold as the technical data, and software which implements them, become the key to the manufacturing process.

The Computer

Not surprisingly, the computer is on the list of emerging technologies. The impact of the machine, a technology that is less than 40 years old, dictates much of the development of the remaining six technologies. Computerization includes the supercomputer, Artificial Intelligence (AI), and computer techniques. Software is of growing concern as well, as computer power is enhanced through new programs and programming techniques. In fact, *The Wall Street Journal* reports, "Corporate computer programmers...now spend 80% of their time just repairing software and updating it to keep it running."[8]

The computer, as we have seen, has had an impact on manufacturing. It has been the basis of FMS, robot assembly lines, computer aided design and manufacturing, and a host of other innovations. It has changed the way we do business and caused us to reevaluate corporate structures. It has touched so many areas of our lives and so permeated our thinking that it seems to have been with us forever. In spite of this impression, the computer has just begun to be taken seriously as a machine that is not just a tool, but a way of functioning.

Computer-Aided Acquisition and Logistics Support (CALS) is a familiar example of how the computer has influenced logistics. Logistics Support Analysis Records (LSAR) have been automated as have R&M programs and an array of other requirements necessitating mathematical calculations and record keeping. Yet the software that is available for a myriad of tasks is not being used to its fullest.

One example was uncovered by a study made by the Department of Defense and two other government agencies which showed that packaged software testing tools are used by less than 25% of the organizations developing software.[9] If logistics engineers are to lend support to the software programmer and account for software development, they will have to support the use of testing tools within a project. Support in this case should include documentation, procedures, and training. To be better able to supply guidance and control in all areas of software, however, the LE must make software part of the logistics education.

As computer hardware and software are standardized, or at least made user-friendly enough to be understandable without lengthy training sessions, some of the resistance to computerization should diminish. However, greater acceptance and ease of use may bring some of its own problems. The logistics engineer must always keep in mind that, as more and more information becomes available, it is increasingly important to filter out only what is essential. BC (before computers) it was necessary to get enough information to answer a question; now AC (after computers) it is imperative to ask the right questions.

As automated and computerized manufacturing take hold, the reliability of what is produced should arise. This expectation is based, in part, on the ability of the designers and other supporting disciplines to establish specifications and standards that make the most of the machinery. With simulation and modeling, it will also be easier to predict the limits of what can be specified. It should likewise be easier to test for adherence to those specifications as automated testing is implemented. The result of tightening requirements can be over-specification and the consequent elimination of perfectly capable, but nonautomated, companies from contract awards. The question that must be asked by the logistics engineer in this instance, then, is: What are the limits? Can maintenance personnel maintain the precision that was built into a product or is it even necessary to do so? Human factors should become as much a part of an LE's evaluation as R&M, transportability, or any other consideration.

Computers will not only affect what the logistician does but how it is done. The availability of information via the computer is expanding rapidly. The personal computer holds more and more data as hard drives and more complex IC chips become available. Phone lines now carry electronic mail, facsimile transmissions, and electronic bulletin boards, and give access to distant computer data banks by modem. While much of this promises the "paperless" office, the truth is that the amount of paper being handled has multiplied. In the same way that the photocopy machine gave individuals their own private library, the trend to powerful, individual computers allows a myriad of private data banks to be established, with the same information being entered again and again. If there is a fear clerical jobs are disappearing, the proliferation of data entry clerks may more than compensate for the loss of secretarial personnel.

The logistics engineer can easily see the repercussion of the repeated entry of information. Each input can generate new errors, not to mention the expense inherent in the repetition of a boring task. Optical readers, as they improve, may alleviate some of the problem, but the logistician must anticipate handling data entry, and the information itself, in a new way. Now is the time to develop the management principles which must govern computer technology. Standards need to be developed and adhered to; the logistician is in a good position to start generating some of those requirements.

What form the requirements will take depends on the evolutionary path of today's technology. At what point automation will be embraced nationally will determine when a

particular standard can be enforced. Can we request that all parts, or perhaps all modules, be marked with a bar code or similar identification so their code can be fed directly into any computer? Some bar coding has been done for inventory control in different companies.

The manner in which information is stored and printed has become cumbersome. The LSAR, which was conceived as a way of storing large quantities of related data in one place, is used far less than it ought to be. LEs need to consider not only methods of user-friendly input but user-friendly output as well. The LSAR of the future should not only be used to supply the information for technical manuals but be able to generate rough copies of technical orders directly from its data base.

The production of manuals and other documents, according to *The Wall Street Journal*, accounts for about 6% of the cost of complex weapon systems. It is no surprise, then, that the Pentagon has mandated that starting in 1990 manuals must be produced on computerized publishing systems. With as much as 25% of military documents out of date at any one time and with new technology changing the face of military systems more quickly, technical writers will need to turn to easily accessible sources of information.[10] The LSAR must be ready to accommodate them.

The upcoming generation has been raised on television and responds well to visual instruction. With a less-educated pool of labor, video instructions also compensate for a lack of reading comprehension. Technical writing may go beyond putting words on paper to include devising computerized and video teaching modules. The LSAR should eventually be able to be used for video manuals as well as transfer into hard copy.

Electronics

Microelectronics, optoelectronics, and millimeter wave technology are mentioned in the National Bureau of Standards study. The most prominent new discovery in electronics is the superconductor. Still in its infancy, the impact the eventual development of near-zero resistance conductive materials may have on society ranges from the creation of superconducting cables which could lower transmission costs by billions of dollars to high-speed trains which are powered magnetically.

Electronics is driving computer development, telecommunications, advanced weaponry, and the needs of sophisticated production and information systems. Almost as if in response to the job force profile, electronic equipment is being generated to function in a growing number of tasks. The oscilloscope, along with other familiar test devices, may go the way of the slide rule as new types of test equipment are carried into the field; used to test and evaluate the problem electronically; and, in some cases, even make repairs.

Biotechnology

Genetic engineering and biochemical processing have an impact on chemical manufacturing and the development of new materials and thin-layer technology. Biotechnology, while it does not directly affect logistics, should be watched since its R&D labs are the source of many of our new materials, ways to control the environment, and other developments which affect so many other fields. Biotechnological warfare, or the methods by which it must be combated, is yet another reason to keep up with biotech developments.

Advanced Materials

Advanced metals, polymer composites, and high performance ceramics are slowly edging out older materials and the old specifications which governed them. It seems increasingly clear that the manufacture of durable goods will be polymer-based. The attributes of these new plastics are: lightweight, less susceptibility to corrosion, reduced cost (because they need less finishing), and resistance to wear. Ceramics, magnesium, and other nontraditional materials have similar attributes and are seeing increased use.[11] For the logistics engineer the shift to advanced materials creates a new problem—all the handbooks used tend to be based on steel. For technical documentation to be readily available, data must begin to be compiled.

Medical Technology

New drugs and medical devices which improve diagnosis and treatment of disease may seem removed from logistics, except on a personal level. But the work force is aging and the number of educated young people has dropped to the point that industry may look to the elderly to meet employment demands. An extended life span, coupled with an extended working life, may change the thrust of not only how people are trained, but when.

Thin Layer Technology

Ultrathin layers of chemicals are improving the capability of products, especially in electronics. Such innovations as diamond coating computer chips are leading to EMP-hardened components.

Human Factors

Recalling Keynes, there are times when planning for the unexpected can be the best defense. In the short term, it is only reasonable to expect that, with the proliferation of easily accessible information, security will become an increasingly controversial issue. How to cope with changes in the makeup of the labor force, once plentiful and now diminishing, is also of growing concern. Global markets can change, and have changed, how we do business. Even the manner in which wars are being waged has repercussions for the way we must plan for the future.

Recent missile treaties have caused some European countries to anticipate attack by conventional means. Low-intensity conflicts, peacekeeping missions, and response to terrorist activities all involve small arms and less sophisticated weaponry. Army Major General Barry R. McCaffrey has argued that small arms are refinements of hardware that has been in use since the American Civil War. He suggests that developers take new approaches using technologies emerging from other defense industry programs.[12] Based on the armed conflicts that have

been taking place recently, General McCaffrey's idea, and other ideas which could change the shape of basic arms, may find funding.

Foreign competition is another area with which the logistician must be concerned. Just considering military purchases, the Pentagon spent $9 billion for foreign parts and equipment in 1987, up from $5.4 billion in 1981. The military concedes that, should a global crisis take place, foreign-made parts might not be available.[13] In a recently conducted survey of some 200 manufacturing companies, competitiveness ranked as the number one concern. The companies interviewed believed that customer service could offset manufacturing advantages of foreign competitors who have cost the US manufacturing community about one-third of its world market over the past 20 years.[14]

For the logistics engineer who is often in the position of recommending parts and ensuring that adequate spares are available, making a choice based on quality and cost will not be as simple as it used to be. Not only at issue is the speed at which a part can be reproduced if its source is no longer available, but also whether that industry will exist at all in the US. Capability must be maintained along with availability.

A substantial portion of logistics work is repair and maintenance. Keeping old equipment running and training personnel how to cope with new technologies are all part of the demands placed on the logistics community. A new approach to both training and personnel will be necessary to meet the impact of changing demographics and education. By 1990 the teenage population will have dropped 30% from 1975. The rate at which women are entering the labor force is also slowing. Most of the population over the next 12 years will be between 35 and 59.[15] For the military, unless it retains its older personnel, the statistics spell fewer available recruits.

More education is needed for many of the jobs that technology has created, but schools are not keeping up with the change. More than half a million students drop out of high school each year and many who do graduate are all but illiterate. The drop in college-age students also means that there will be fewer highly educated employees.[16] LEs may soon find that they are becoming educators along with their other duties.

Conclusion

Overall, what will the future look like for a logistics engineer? Isaac Asimov commented that it is easier to foresee the automobile than it is the traffic jam. To predict what will happen next, it is certainly easier to say, for instance, that LEs will be using the computer a lot more than it is to predict how. However, a few things seem certain. Logistics must be considered earlier than ever and become more a part of the total process in product development. Knowledge about the computer, and specifically software, will be absolutely essential. Training and instructional documentation will also be increasingly important. There will be greater security precautions and control of information as data flow over national and international computer networks. Foreign competition, too, will affect how we provision essential goods. One way or another, the world of logistics will be changed. By anticipating what is to come, we, as individuals, will be ready to change.

Notes

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▶ *Continued from page 35*

adopting more demanding acquisition strategies and procedures. This initiative will apply to vehicles such as fire trucks, refuelers, aircraft loading equipment, etc. (Lt Col Randall Cox, AF/LETN, AV 227-3371)

Acquisition Program Baseline

Acquisition logistics is receiving emphasis in the streamlined weapon system acquisition management process. The cornerstone of this process is the acquisition program baseline. The baseline is a contract between the program manager and the Air Force acquisition executive. This document includes a description of the program, the required funding, schedule of key events, technical and operational requirements, and any requirements which must be deferred. The baseline then allows the acquisition executive to measure the progress of the program. To ensure the Air Force commitment to supportability is reflected in the baseline, logistics factors were highlighted in the latest baseline policy guidance. New supportability factors will be required in the baseline; for instance, the maintenance concept will be added to the program description to provide an understanding of the full operational environment of the weapon system. R&M parameters in the operational performance section of the baseline should reflect improvements in combat capability, mobility, vulnerability, and manpower. Support resources which are not normally under the control of the program manager (common support equipment, interim contractor support (ICS)) will also be added to provide a comprehensive support funding picture. By providing a better definition of the logistics support efforts in a baseline, the acquisition, support, and user communities know what is to be delivered and when. (Maj Michael Carpenter, SAF/RL, AUTOVON 225-7984)

AIR FORCE JOURNAL of LOGISTICS

Through the history of world aviation
Many names have come to fore.
Great deeds of the past in our memory will last,
As they're joined by more and more.
When man first started his labor in his quest to conquer the sky
He was the designer, mechanic and pilot,
And he built a machine that would fly.
But somehow orders got twisted,
And then in the public's eye
The only man that could be seen
Was the man that knew how to fly.
The pilot was everyone's hero,
He was brave, he was bold, he was grand,
As he stood by his battered old biplane
With his goggles and helmet in hand.
To be sure, these pilots all earned it,
To fly you have to have guts
And They blazed their names in the Hall of Fame
On wings with bailing wire struts.
But for each of these flying heroes
There were thousands of little renown,
And these were the men who worked on the planes
But kept their feet on the ground.
We all know the name of Lindbergh,
And we've read of his flight into fame
But think, if you can, of his maintenance man.
Can you remember his name?
And think of our wartime heroes, McConnell, Jabara, and Ritchie.
Can you tell me the names of their crew chiefs?
A thousand to one you cannot.
Now pilots are highly trained people,
And wings are not easily won.
But without the work of the maintenance man
Our pilots would march with a gun.
So when you see mighty jet aircraft
As they mark their way through the air,
The grease stained mechanic with the wrench in hand
Is the person who put them there.

This guide is dedicated to the men and women of George A.F.B. who maintain the aircraft and those who, in their special way, help keep 'em flyin'.

George AFB Guide, 1985 edition